ALTERNATIVE ENERGY GENERATION SYSTEM FOR PINSENT'S ARM AND NORMAN BAY, LABRADOR

A Feasibility Study

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Prepared for:

East Shore Labrador Development Association

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With a contribution from:

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EXECUTIVE SUMMARY

A study was undertaken by Provincial Consultants Ltd. on behalf of the East Shore Labrador Development Association, to investigate the financial and technical feasibility of a remote village alternative energy electric generation system for the communities of Pinsent's Arm and Norman Bay, Labrador.

The project compared the life cycle costs which included initial capital, operating and maintenance costs of a new standard diesel electric generation system against five alternatives. The following are the six systems and their corresponding capital costs:

(1)	Standard diesel electric generation	431,000
(2)	Cycle charge*/diesel electric system	699,800
(3)	Photovoltaic/cycle charge/diesel electric system	914,000
(4)	Wind energy conversion/cycle charge/ diesel electric system	762,900
(5)	Photovoltaic battery system	3,993,700
(6)	Wind energy conversion battery system	1,098,900

The cycle charge system is by definition a diesel battery system. The diesel operates during periods of low battery charge, peak demand or the combination of these two conditions thereby reducing the running time of the diesel during low load conditions.

Neither community presently has a utility supplied central electric generation system.

The study concludes that all the alternative energy electric generation systems are not economically feasible at the present time because of the combination of high capital and low system efficiency. The cycle charge diesel electric system may be economical after the turn of the century if the capital costs can be brought down and the system efficiency improves.

It is recommended that a cycle charge diesel electric system be installed in a Newfoundland or Labrador community to verify the fuel savings projected for this system if the following criteria can be met.

(1) The community has an existing diesel electric A.C. distribution system between 10 to 150 kW in capacity, and
(2) The community will not be a candidate for grid inter-tie for the next twenty years.

Therefore, a reliable technical data base can be established to determine the fuel savings, the system reliability, manpower requirements, and battery maintenance for the proposed system.

The estimated capital cost to implement a 125 kW cycle charge demonstration project is $230,000.

*Cycle charge is a registered trademark of Mechron Ltd.

SYSTÈMES DE PRODUCTION D'ÉLECTRICITÉ DE RECHANGE POUR PINSENT'S ARM ET NORMAN BAY (LABRADOR)

Résumé

La présente étude menée par la Provincial Consultants Ltd. au profit de la East Shore Labrador Development Association visait à examiner la rentabilité et la faisabilité technique d'un système de production d'électricité de rechange pour les collectivités éloignées de Pinsent's Arm et de Norman Bay au Labrador.

L'étude compare les coûts (y compris l'investissement initial, les frais d'exploitation et d'entretien) sur la durée prévue des installations pour obtenir une comparaison entre une nouvelle centrale électrique alimentée au diesel et cinq autres options. Les six options et leurs coûts capitaux sont les suivantes:

(1) Centrale alimentée au diesel:	431 000 $
(2) Groupe électrogène "Cycle Charge"* alimenté au diesel;	699 800 $
(3) Groupe électrogène "Cycle Charge" alimenté au diesel, muni d'un générateur photovoltaique;	914 000 $
(4) Groupe électrogène "Cycle Charge" alimenté au diesel, muni d'un système de conversion d'énergie éolienne;	762 900 $
(5) Système photovoltaique à batteries, et	3 993 700 $
(6) Système de conversion de l'énergie éolienne, à batteries.	1 098 900 $

Le système "Cycle Charge" est un système diesel muni de batteries dont le chargement se fait de façon cyclique. Le diesel fonctionne pendant les périodes de faible charge des batteries et de demande de pointe ou une combinaison de ces situations, ce qui réduit la durée d'exploitation du diesel pendant les périodes où la demande est faible.

Ni l'une ni l'autre des deux collectivités n'a maintenant une source centrale d'électricité fournie par un service public.

L'étude conclut que tous les systèmes de production d'électricité de rechange ne sont pas rentable maintenant, étant donné son coût élevé en capital et le peu de rendement du système, l'option pourrait cependant devenir rentable dans une dizaine d'années, si le coût en capital est diminué et le rendement du système amélioré.

---

*"Cycle Charge" est une marque de commerce enregistrée de la Mechron Energy Ltd. d'Ottawa.

On recommande l'installation d'un groupe électrogène "Cycle Charge" alimenté au diesel dans une collectivité à Terre-Neuve ou au Labrador afin de vérifier les économies de combustible projetés pour ce système, si les critère suivants peuvent être obtenus.

1. La collectivité a un système de distribution d'électricité C.A. alimenté au diesel d'une capacité variant entre 10 et 150 kW.

2. La collectivité ne sera pas lier au réseau d'électricité de la Newfoundland and Labrador Hydro pour les 20 prochaines années.

Une base fiable de données techniques peut être établie pour déterminer les économies de combustibles réalisables, la fiabilité du système, les besoins en main-d'oeuvre et les exigences relatives à l'entretien des batteries pour le système proposé.

Le coût total en capital estimé pour effectuer un projet de démonstration "Cycle Charge" de 125 kW est 230 000 $.

La présente étude à été réalisée à l'aide d'une contribution financière versée à l'East Shore Labrador Development Association par le Programme de démonstration dans les collectivités éloignées, d'Énergie, Mines et Ressources Canada.

INTRODUCTION

This is the final report of a study to investigate the technical and economic feasibility of alternative energy generating systems for remote communities. This study is undertaken within the Remote Community Demonstration Program (RCDP). The forms of alternative energy under investigation are solar driven (photovoltaics) and wind driven (wind turbines). The intent of the RCDP is to identify more appropriate energy alternatives and to help remote communities achieve greater energy self-reliance, lower long-term energy costs, and where applicable, increased levels of electrical service. Eligible communities are identified as being located in the two territories or in that part of a province that is not located on an electrical grid or served by a natural gas pipeline, and have at least 10 occupied principal residences.

The two communities included within this study are Pinsent's Arm and Norman Bay, with a population of 51 and 56 respectively. They are located on the southeast coast of Labrador. Pinsent's Arm is a continuously occupied fishing community with a static population, while Norman Bay is a winter community with its population moving to various fishing communities for the summer. Both communities at present are without a continuous electrical supply.

The electrical generating system (designs) utilizing alternative energy to supply a remote community are compared technically and economically to the standard utility design. This provides a reference point to identify the extent of cost advantage, if any exists, for a particular alternative energy system. A basic criteria of a system is that it supplies a level of electrical service comparable to that existing in remote communities presently with electricity.

The system designs are configured around the two communities previously mentioned. Chapter One of this report presents background information including, calculations of household and community loads, the various alternative energy systems available, the methodology of technical analysis of the various systems, and present worth analysis of these systems. Chapters Two, Three and Four discuss in detail the requirements of the standard diesel and new cycle charge systems, photovoltaic and wind energy conversion generating systems, design considerations, site specific requirements and resultant analysis respectively. Chapter Five discusses the life cycle costs of each competing system. Chapter Six identifies the system maintenance and reliability, the economic advantages of utilizing alternative energy technologies, presents the description for the optimum (lowest present worth value) electrical generating system for Pinsent's Arm and for Norman Bay, and makes recommendations and conclusions.

1.0 SYSTEM OVERVIEW

1.1 BACKGROUND

The communities of Pinsent's Arm and Norman Bay are typical of the majority of the communities in Labrador (Figure 1.1). They are remote, not connected by road to any other populated center, and have a small population. Pinsent's Arm is occupied year-round while the people of Norman Bay's move closer to the fishing areas during the summer fishing season. All other communities but these two are supplied by electricity generated from centrally located diesel powered equipment. The utility responsible for running the equipment and associated distribution equipment is the Power Distribution District of Newfoundland and Labrador Hydro. The standard diesel generator layout for a remote community is three generators of approximately the same electrical rating, along with a building to house the equipment and fuel storage tanks. The diesels are sized sufficiently large so that if the largest unit is out of service the remaining units can meet the community's peak load. Because of this, a generator has larger capacity than the typical load drawn by the community over the 24 hour-a-day operating situation. As a result of this partial loading, poor fuel efficiency (fuel consumed per kilowatt-hour generated) and higher than necessary maintenance efforts occur.

There is no means of electrical energy storage necessitating the acceptance of the adverse effects of continuous running of a diesel generator in a remote community. Alternative energy generating technologies exist to supply all or a part of the demand for electricity in these communities.

1.2 SITE VISIT

One of the main purposes of this study has been to determine the technical feasibility of renewable energy sources at both communities. In order to fulfill this purpose it was necessary to visit both communities to determine the following items:

(1) photo documentation of existing facilities such as house locations, housing types and industrial/commercial facilities if any,
(2) preparation of community dossiers similar to the format found in the BRADOR (1983) report,
(3) documentation of all existing energy consumption patterns and determination of future energy demands, and
(4) identification of potential sites for possible photovoltaic arrays and Wind Energy Conversion Systems (WECS).

Item (2) is presented in Appendix 1.0. Items (3) and (4) are further discussed in Section 1.2 Residential Energy Consumption, Section 3.4 Solar Radiation in the Battle Harbour Region, and Section 4.4 Wind Energy Potential in the Battle Harbour Region.

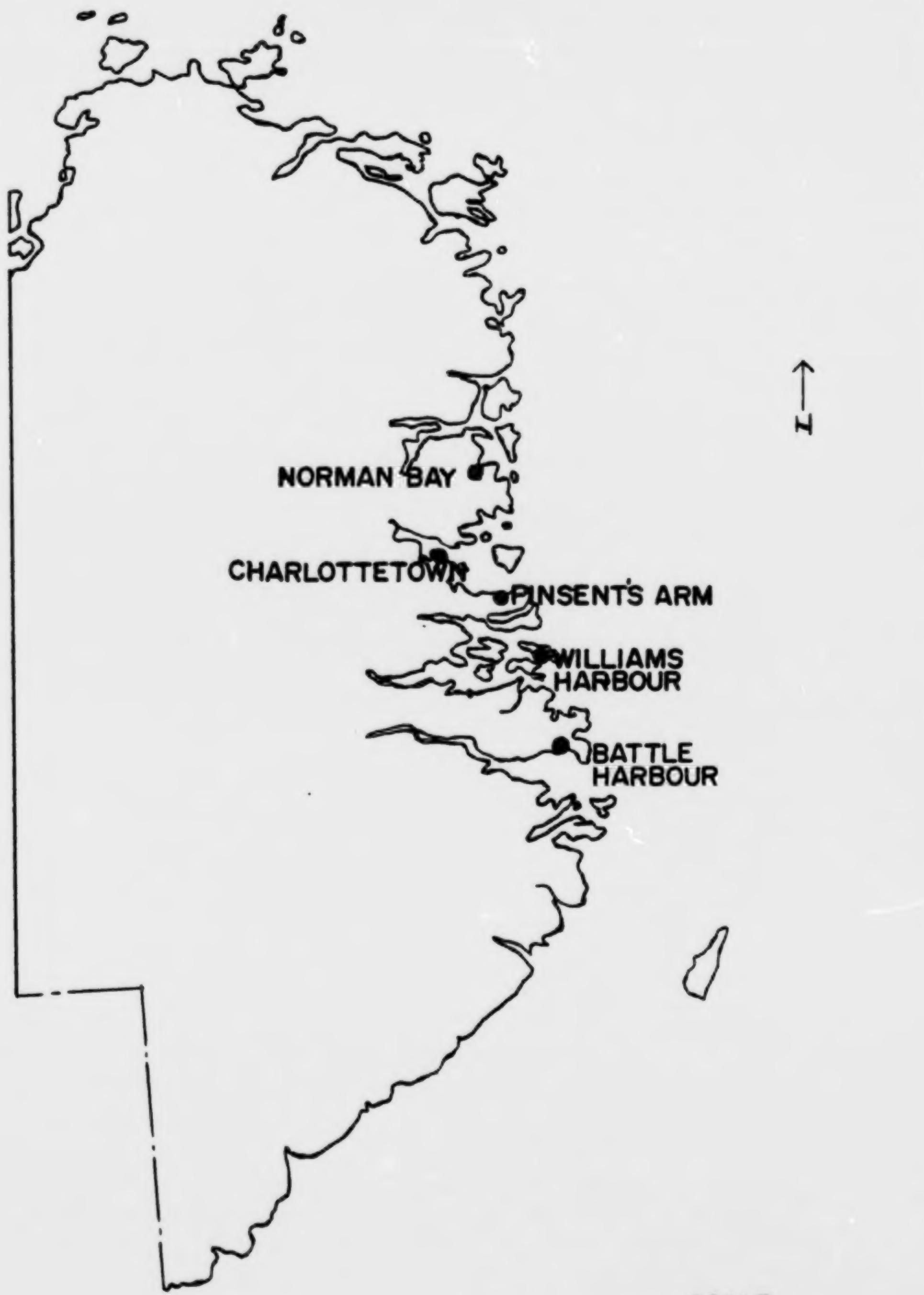

NORMAN BAY
CHARLOTTETOWN
PINSENT'S ARM
WILLIAMS HARBOUR
BATTLE HARBOUR
N
SCALE
km 25
0
25
50

FIGURE 1.1

MAP OF STUDY AREA - SOUTH-EAST LABRADOR

1.2.1 Site Survey at Pinsent's Arm

Pinsent's Arm is a year round fishing village with a population of 51 located in the northern side of Pinsent's Arm as shown in Figure 1.2. The area is hilly with individual peaks rising to 200 meters within 2 kilometres of the village. The land where the village is sited forms a small peninsula oriented to a NE-SW axis. The houses are located with the major axis located E-W and the minor ones located N-S.

The soil conditions of the community vary from bog very close to the houses to rock outcrops on the rises and the top of the largest hill close to the community.

The water depths by the community are quite shallow with a tide range of 1.0 m. Discussions with local fishermen indicate that the fuels for the diesel generator at the fish plant and the snowmobiles are brought to shore by open boats.

1.2.2 Site Survey at Norman Bay

Norman Bay is the winter settlement for some of the residents of communities such as Venison Tickle and Snug Harbour. Its population from September to June is 56. As of the middle of June the community is deserted until residents move back in mid September. The surrounding area is hilly with numerous salt water bays and freshwater lakes. Norman Bay is broken up into 2 sections; the main housing base on Norman Bay and several scattered houses on Martin Bay and Trout Cove as shown in Figure 1.3. These are approximately 1.2 km. apart from the main settlement. The houses are located with the major axis located E-W and the minor axis located N-S.

The soil conditions of the community vary from boggy around the houses to rocky hills to the north and wooded hills to the south.

The water depth in Norman Bay is deeper than Pinsent's Arm. This would allow large vessels such as tankers to move in closer to shore. However there are no wharf facilities.

1.2.3 Charlottetown

Charlottetown is the service centre for both Norman Bay and Pinsent's Arm. It has a population of 250 people as of 1981. It is served by a diesel system for electricity consisting of one 60 kW Deutz and two 36 kW Caterpillar gensets.

1.2.4 Williams Harbour

Williams Harbour is the smallest community of the Labrador coast which is served by diesel electric power. It has a population of 78 as of 1981. The description of the diesel electric system is found in Section 2.1.

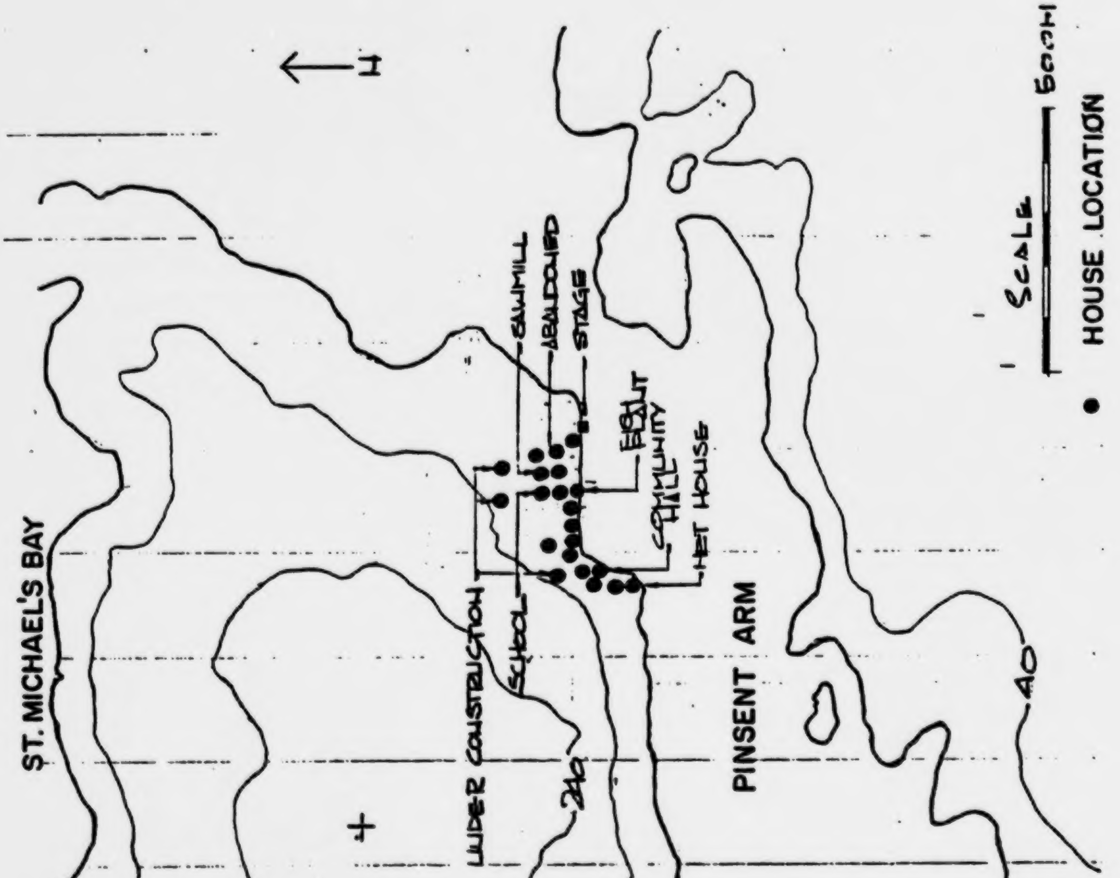

N
ST. MICHAEL'S BAY
PINSENT ARM
UNDER CONSTRUCTION
SCHOOL
SAWMILL
ABANDONED
STAGE
FISH PLANT
COMMUNITY HALL
NET HOUSE
240
40
40
200
SCALE
500M.
● HOUSE LOCATION

FIGURE 1.2

MAP OF PINSENT'S ARM

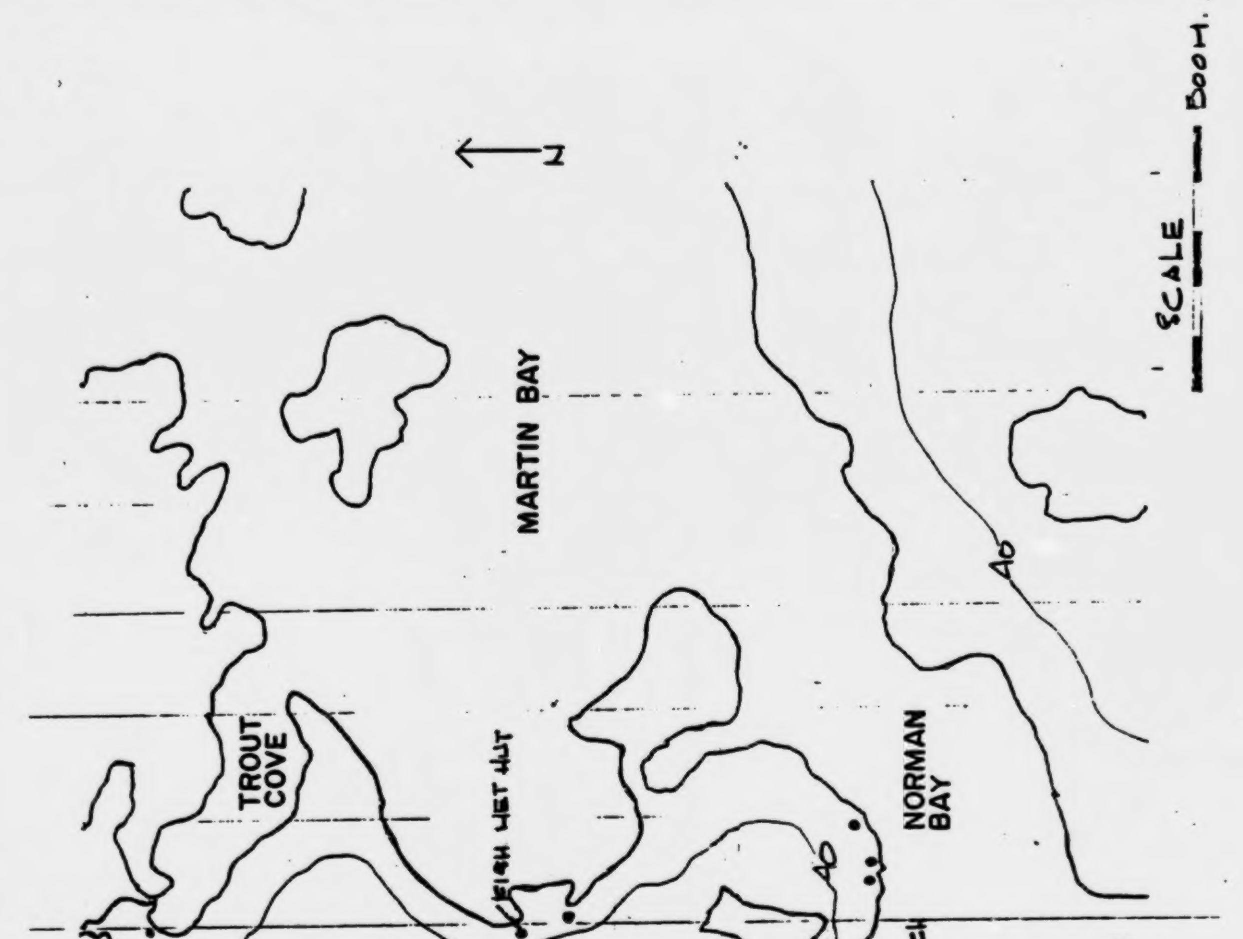

N
SCALE
800M.
MARTIN BAY
TROUT COVE
FISH NET HUT
NORMAN BAY
40
40
200
240
CHURCH
School
OSBERNS POND
● HOUSE LOCATION

FIGURE 1.3

MAP OF NORMAN BAY

1.3 RESIDENTIAL ENERGY CONSUMPTION

At present the two communities are generating electricity on an ad hoc basis and neither has electricity routinely.

The total energy consumption for each community is found in the Community profiles in Appendix 1.0.

1.3.1 Energy Usage at Pinsent's Arm

A government owned diesel generator rated at 15 kW is located within the community to provide electricity for the fishing stage. The people have installed a makeshift system to distribute electricity to their dwellings. They occasionally run this machine to power their washing machines, lighting and miscellaneous household appliances. There are no motor driven appliances in the residences other than the washing machines. Some households have several electrical hand tools.

The fuel consumed by this diesel generator is purchased by the residents and annually amounts to approximately 6400 litres. Space and water heating, and cooking are accomplished with wood fueled stoves. Approximately 130 tonnes of softwoods and birch are used annually, requiring about 5000 litres of gasoline to power snowmobiles and chain saws for the community's wood supply.

1.3.2 Energy Usage at Norman Bay

Norman Bay is a community similar in size and energy needs but does not have access to a large diesel generator as does Pinsent's Arm. Therefore, there are no miscellaneous electrical appliances, lighting is by kerosene lamps consuming 2900 litres. Three families have small gasoline or diesel generators for powering washing machines and assorted tools, consuming a total of 500 litres of fuel. The community's wood fuel usage is 130 tonnes requiring the consumption of 5000 litres of gasoline to obtain and prepare the wood for use.

1.4 RESIDENTIAL ELECTRICAL ENERGY SYSTEM DESIGN

Based on information received from Newfoundland and Labrador Hydro on 1984 08 22 the average residence in a remote Labrador community can consume from 2000 kWh to 3600 kWh per annum. For design purposes in this report, an average consumption of 3600 kWh per annum will be used to determine the final configuration sizes of the alternative energy electric generation systems. (See Section 2.1 for Standard Diesel Genset configuration).

1.4.1 Diesel Generating System

The generator sets previously described would be located in a common building containing ancillary equipment for manually starting the generators and keeping them running. Fuel storage would be required outside the building sized for a year's fuel consumption. The arrangement includes manual human monitoring. The generator sets output energy at 600 volts, Alternating Current (600 V.A.C.) which is stepped up to 4160 V.A.C. for distribution throughout the community. This voltage is then stepped down to 120 V.A.C. for distribution at the individual residences. This step up and step down of voltages is to lower the distribution losses associated with the lower voltages and to reduce the wire sizes in the distribution system. In North America 120 V.A.C. is a standard utilization voltage for residential and light industrial distribution. A similar system to the one above would have to be constructed in Pinsent's Arm or Norman Bay if either community was to receive electricity from the utility.

1.5 ALTERNATIVE ENERGY TECHNOLOGIES

Before making a decision on implementing the above described diesel generating system the attributes of alternative technologies for generating electricity should be considered. The technologies of photovoltaics (solar cells, the direct conversion of solar radiation into direct current electricity) and wind energy conversion (wind turbine, in the context of this report the conversion of the kinetic energy of moving air into direct or alternating current electricity) are presently in use throughout the world. Generally the applications of alternative energy systems are in remote areas where connection to a utility grid is very expensive, due to the cost of distribution from the main grid or where the load is very small.

1.5.1 Photovoltaic Applications

The Department of Transport, Coast Guard are using photovoltaic (PV) arrays for navigational aids in remote areas. The harbour range light in the middle of St. Anthony harbour, Newfoundland has a PV array mounted on it to power the light. They have more than 500 PV systems in operation with an average payback of less than 2 years (Photovoltaics Technique, December 1982).

Mr. B. Higgins, Paradise River, Labrador, supplies his own electrical demands with a gasoline generator. He installed a PV gasoline battery system (complete with a charger) as an energy storage system during November, 1984. This arrangement allows less generator running time per day at a higher kWh/fuel consumed because the generator is running at near full load when in operation. The net result is reduced fuel consumption. Mr. Higgins' intent is to purchase more photovoltaic equipment with the savings from displaced fuel.

1.5.2 Wind Turbine Applications

Today there are residences receiving part or all of their electrical energy requirements from wind. Mr. R. King, St. John's, Newfoundland has a 2 kW wind turbine which generate 12 Vdc to power lighting, shallow well pump, miscellaneous appliances and a battery charger. He receives power from a battery bank to meet surge loads and loads during low wind energy periods. Mr. R. Brandt; Yellowknife, Northwest Territories has a 3 kW wind turbine to provide electrical power to his residence and has a battery arrangement similar to Mr. King. Mr. Brandt has a 10 kW diesel generator to handle peak residential loads.

Several locations in the United States; California and Hawaii, amongst others generate electricity using the wind to drive arrays of wind turbines on towers (wind farms). Wind farms are interconnected to utility distribution systems for selling the produced electricity.

Newfoundland and Labrador Hydro have an ongoing multi-year testing program of a 50 kW turbine interconnected to their grid.

1.6 ALTERNATIVE ENERGY SYSTEM CONSIDERATIONS

At present, an electrical generating system in a remote community involves a central diesel plant and a distribution grid. An alternative energy system can follow this approach or can go the route of individual household systems. Individual systems would preclude the use of a distribution grid. PV arrays generate direct current electricity with the arrays wired in series and parallel to obtain the required voltage and rated current. Wind turbines generate direct and alternating current. Alternating current models are intended for generating into large utility grids; leaving direct current models for remote communities. Direct current would require conversion to alternating current if a central generating concept is implemented. However, if household alternative energy systems are utilized the majority of the household loads could be operated on direct current. The energy consumption of motors and other equipment requiring alternating current would be satisfied through a direct/alternating current inverter.

PV and Wind technologies are both limited by either's energy production being dependent on external factors.

The electrical output from a PV array is proportional to the intensity of the incident solar radiation. The output is adversely affected by precipitation, ice build-up and cloud cover, and varies seasonally and diurnally. This necessitates the use of batteries to store the peak diurnal output to allow electricity consumption after sunset, and for consumption during cloudy days.

1.6 ALTERNATIVE ENERGY SYSTEM CONSIDERATIONS (Cont'd)

The output from a wind turbine is proportional to the cube of the wind speed. During periods of calm or low wind speeds there is none or very little electrical energy. High wind speeds dictate the automatic or manual control of the turbine's speed of rotation, required to allow the continuous production of electricity during those periods.

The energy generated from alternative electric generation systems supplying a residence is typically low, one to five kWh daily. However, the standard residence, without electric heating, connected to an electric grid consumes up to 20 kWh per day. The reason for the low consumption is the capital cost of alternative technology which is being borne by the individual homeowner. An optimum electrical generating facility would be a blend of standard technology, diesel generators, and alternative technology. This will allow reduced capital cost since the diesel generators more easily meet the short duration peak loads of a community. Computer program packages (see Section 1.7) have been used to assist in optimizing the alternative energy systems of photovoltaic and wind turbines, and to complete economic analyses involving life cycle costing of the alternative energy systems, hybrid configurations, and the standard diesel generator.

1.7 ANALYSIS METHODOLOGY

1.7.1 PV F-Chart Software Description

The computer software chosen to analyze the solar cell component of the overall system design is PV F-Chart developed by F-Chart Software (Middleton, Wisconsin, USA). This software is designed to evaluate the performance of PV systems with flat plate or concentrating types of solar collectors which can be fixed or able to track the sun. The program can estimate the long term average performance of:

1. Utility Interface Systems
2. Battery Storage Systems
3. Systems with No Interface or Battery Storage.

1.7.1 PV F-Chart Software Description (Cont'd)

The program uses life cycle economics to determine the optimum system from a cost standpoint. The technical parameters used as inputs into the program are shown in Table 1.1.

TABLE 1.1
TECHNICAL PERFORMANCE DATA
USED IN PV F-CHART

Arco Block V Performance Data

Cell Efficiency:	13.5%
Fill Factor:	.74
Array Reference Temperature:	28° C
Cell Temperature at NOCT Conditions:	48° C
Area:	13.04 m^2/kWp

Supplementary Assumptions

Array Slope:	Latitude - Spring and Autumn Latitude - 15° - Summer Latitude + 15° - Winter
Power Conditioning Efficiency:	88%
Battery Efficiency:	80%
Ground Reflectance:	.6 for December, January, February .4 for November and March .2 for all other months

1.7.2 Duration Statistics Software Package (DUST)

DUST is a program developed by the Atmospheric Environment Service of Environment Canada to analyze historical climate data. The software is used to identify the wind regime of coastal Labrador using Battle Harbour, Labrador climatic information. The output from the DUST identifies the following:

a) percentage of time per month in selected wind speed classes (ie: 0-5 knots, 5-15 knots, etc.)

b) duration of periods of time that the wind speed remained below or above a certain wind speed.

This output allows the best matching of a wind turbine's performance characteristics with the region's wind regime.

1.7.3 Life Cycle Costing

The total present worth of any one electrical generating system is the initial capital cost plus the present worth of the annual costs over the life of the System. The annual costs include; battery maintenance and replacement, labour, fuel costs, parts replacement on a diesel, wind turbine, and/or solar cell distribution components.

In addition to this method of life cycle cost analysis, an alternative cost analysis has been used to develop the real levelized cost per kilowatt-hour for each system. This cost analysis produces the cost per kilowatt in current dollars brought back to a net present value by using a present worth escalation factor which accounts for the effect of inflation and the discount rate of the money or cost to borrow. A further explanation is found in Chapter 5.

2.0 DIESEL SYSTEM TECHNOLOGY

2.1 STANDARD DIESEL ELECTRIC GENERATION SYSTEM DESIGN

Newfoundland and Labrador Hydro's Power Distribution District follows a certain procedure when sizing a diesel plant for the Labrador coast. A brief outline describes their design philosophy as follows. P.D.D. standard procedure is to ensure that the diesel plant firm capacity is never less than the system peak, where the firm capacity is the total installed capacity minus the capacity of the largest installed unit. Therefore, there is always sufficient firm capacity to meet the peak since access to these communities is very difficult during spring break up and autumn freeze up.

To choose the size of the diesel sets one must take into consideration that the daily peak load is usually 3 times the minimum night load and the diesel gensets are usually most efficient when running at 75 to 100% of their rated capacity. Therefore, it is good design policy to have 1 small unit to meet the night load. The smallest machine is then turned off and the larger unit is switched on for daytime running. The larger unit is sized to handle the daytime load except at noon and supper peaks where the two machines may be required. Therefore the standard diesel set (genset) for Pinsent's Arm or Norman Bay is outline in Table 2.1. This design philosophy of having sufficient capacity to meet the peak loads is carried through in all the alternative system designs.

TABLE 2.1
STANDARD DIESEL GENSET FOR
PINSENT'S ARM OR NORMAN BAY

System Load

Peak kW	30 in 1989
Average kW	6 kW in 1989
Average kWh	3600 kWh/household
Average No. of Households between 1985 and 1989	15 in 1989
Diesel Set Required	40 kW; 25kW; 12.5 kW

As previously mentioned in the introduction, a standard diesel electric generator design consists of two or three generators supplying an AC distribution grid at 4.16 kV.A.C. Williams Harbour located at 52° 33' N latitude and 55° 47' W longitude, is the smallest southern Labrador community which meets the Newfoundland and Labrador Hydro's requirements of 15 permanent residences for a diesel electric system. It has a population of 78 as of 1981 and is 16 kilometers from Pinsent's Arm as shown in Figure 1.1.

2.1 STANDARD DIESEL ELECTRIC GENERATION SYSTEM DESIGN (Cont'd)

From information provided by Newfoundland and Labrador Hydro as of 1983, the power plant installed at Williams Harbour consists of 2 generators; one 100 kW Cummins with an Onan generator and one 60 kW Deutz with a Tamper generator. In 1982 the community used 110,589 litres of fuel at a cost of $44,924 which on a per capita basis is 1418 litres or $576. The electricity sold to the community per household was 11800 kWh excluding diesel housekeeping consumption. The peak load demand in 1982 was 83 kW on average.

The purpose of the cycle charge system is to increase the load on the diesel plant to as high as possible. It is described in the following section.

A standard diesel electric generation system has been costed and used as the bench mark of the study. The system design details and life cycle cost analysis are found in Section 5.2.

2.2 CYCLE CHARGE SYSTEM DESIGN

A cycle charge system is the standard genset with the addition of batteries, battery charger and inverter. The overall efficiency of the system is increased by running the genset at higher outputs for shorter periods, charging batteries then turning the engine off and letting the batteries and inverter take care of supplying electricity during the low demand periods such as the night time.

This means that the cycle charge system is the basic building block of the alternative energy design. A wind generator or photovoltaic panels are added to the system to reduce the load to the genset. It should be pointed out that the genset will never be eliminated because it is more reliable than wind or PV systems and it has a much lower installed cost per kWh.

2.2.1 System Design Criteria

From Section 1.4 the load has been calculated to be 110 kWh/day based on Newfoundland and Labrador Hydro standards for a 10-11 household community and the peak demand is approximately 30 kW. Efficient cycle charge system design (Dure, 1984) recommends the following characteristics for the system in Table 2.2.

TABLE 2.2
CYCLE CHARGE GENSET FOR
PINSENT'S ARM OR NORMAN BAY

Rated Power	60 kW (two 60 kW gensets)
Battery Capacity	9 hrs (367 kWh) storage

The rated power is determined by the 15 minute peak as measured by a standard utility demand meter and then doubled to handle the instantaneous (< 5 minutes) load.

2.2.1 System Design Criteria (Cont'd)

The battery capacity is based on the minimum night time load and adjusted for a 30% discharge range of the batteries.

2.2.2 Storage and Conversion Systems

2.2.2.1 Battery Storage Systems

The secondary battery system is the most common method of storing electricity generated by solar, wind or cycle charge systems. The secondary battery is the rechargeable type (ie: the car battery) while the primary battery is single use only (ie: the standard flashlight battery).

There are two main secondary battery types; (1) lead acid, and (2) nickel cadium. A brief discussion of these battery types will follow after a description of some basic battery characteristics.

The capacity of a storage battery is often expressed in ampere-hours over some standard reference time such as 8 hours or 20 hours. Ampere-hour capability would be less or more depending on the rate of energy discharge. For example, a battery rated at 100 ampere-hours in a 20 hour rating will deliver 5 ampere for 20 hours, at 8 ampere the capacity would be less than 100 ampere-hours and at 4 amperes it would be more than 100 ampere-hours.

The depth of discharge is the second main characteristic which is of importance to a battery specification. In a PV battery the depth of discharge will affect the number of cycles the battery can be charged/discharged. If a battery is rated at 1000 cycles or 2.7 years at 15% discharge where one cycle occurs per day and the depth of discharge was increased to 50% then the battery life would be shortened to 300 cycles or 0.8 years. This has a great effect on the cost of battery replacement and must be carefully considered when examining battery characteristics.

Lead Acid Batteries

Lead acid batteries are the most common type used for storage of electrical energy. There are two types (1) the automotive which is designed for shallow discharge and high current draw or (2) the marine battery which is designed for deep discharge and low current draw. A single cell is usually 2.1 volts and depending upon the series and parallel connection the desired voltage and ampere-hour capacity can be built. The most important characteristic of the lead acid battery is that the voltage at the battery terminals varies directly with the state of discharge for most of the discharge range. Therefore, the measurement of charge can be taken easily without removing the battery top and measuring the specific gravity which is the other method.

2.2.2.1 Battery Storage Systems (Cont'd)

Nickel Cadium Batteries

Nickel cadium batteries is the second most common secondary battery type and is gaining in popularity because there is no acidic electrolyte. These batteries can be charged or discharged at any mounting angle. The nickel cadium batteries' main disadvantage is that voltage can not be used to monitor the state of discharge so that it is more difficult to determine the battery's charge state from a remote location.

2.2.2.2 Conversion Systems

An inverter is a device used to convert DC voltage to AC voltage. There are two main types of inverters (1) solid state inverters and (2) rotary inverters.

The solid state inverter uses transistors to convert the DC to AC. They can be further classified as static or synchronous inverters. Static inverters do not need an external AC power source to convert DC to AC where synchronous inverter do. For remote locations the static inverter is preferred because it can generate AC anytime. Synchronous inverters are normally used in utility inter-tie cases. The main advantage of static inverters is the relatively high efficiency 90-95%. Its main disadvantage is limited power handling capacities. Normally the static inverter is rated to 4 times its average load capacity. In cases of short circuits up to 10 times the current may go through the inverter which may cause reliability problems.

The rotary inverter uses a 12 volt DC motor to drive an alternator to produce AC current. Its main disadvantage is its lower efficiency (50-60%). Its main advantage is its short circuit capacity (up to 10 times the average current). Therefore the rotary inverter is more safe in cases of short circuit in closed systems such as the cycle charge system because the battery/diesel generators are sized close to the actual load to keep costs down and therefore require the rotary inverter to be used as a peaking device drawing stored energy from the batteries to assist the diesel.

2.2.3 Operational Systems

The first wide scale use of cycle charge systems have been adopted by Newfoundland Telephone throughout Newfoundland and Labrador. It is believed to be the first of its kind in a North American telecommunications network, if not the first on a large scale anywhere.

After running an experiment at Four Mile Pond the following were the results:

(1) the existing 30 kW diesel was replaced by a 12.5 kW unit,
(2) the battery chosen was a GOULD NAX 2184,
(3) the building is heated with the waste heat from the diesel, and
(4) the savings in fuel consumption was calculated at 70% on the basis of an overall diesel operating time of 29 percent.

Mechron Energy Ltd. of Ottawa has developed a cycle charge hybrid system with either PV or WECS as the renewable energy sources.

The system design details and life cycle cost analysis are found in Section 5.3.1 for cycle charge alone, Section 5.3.2 for PV-cycle charge and Section 5.3.3 for wind-cycle charge.

3.0 PHOTOVOLTAIC POWER SYSTEM TECHNOLOGY

3.1 INTRODUCTION

"The basic light energy converter makes a conversion between photons of light energy and dc electricity. This dc electricity can be used directly, or it can be used indirectly to charge batteries or activate some other type of energy storing method." Photovoltaic (PV) cells work as long as there is light available. This means that energy can be extracted from dull rainy days as well as bright sunny days although at a much lower level. In fact batteries can be charged when there is as little as 3% sun. (Noll, 1981)

This section will briefly outline the PV effect, type of solar cells available commercially, the solar potential in the study area and the basic system design.

3.2 PHOTOVOLTAIC EFFECT

PV cells work on the semiconductor effect. If a certain amount of a selected impurity is added to a good crystalline insulator such as silicon, electrons can be caused to move in the outer valence of the atom in n-type semiconductor material and positive charges (holes) can be caused to move in p-type semiconductor materials. The electrons or holes are caused to move when an external forces such as light or heat is applied to the material. Therefore, a solar cell is the combination of p-n materials put together in series or parallel to produce the desired voltage and amperage at the solar cell output terminals.

3.3. SOLAR CELL TYPES

Solar cells are constructed of the following combinations:

(1) Silicon; crystal and amorphous
(2) Gallium - arsenide
(3) Cadmium sulfide/copper sulfide
(4) Selenium

3.3.1 Silicon Cells

Silicon cells are most widely produced as the crystal type. This is because it is stable and has an adequate (10%) efficiency. Amorphous or uncrystalized silicon shows promise because of the lower cost of production however the efficiencies are only 3-6% with a theoretical maximum of 15% the same as crystal silicon cells.

3.3.2 Gallium - Arsenide Cells and Concentrator Methods

Gallium-arsenide cells are being produced to take advantage of the concentrator/tracking method of collection. Concentrator cells are parabolic troughs Fresnel lens, parabolic dishes or movable mirrored slats to focus the energy to the equivalent of 10 to 500 suns. However, they all must use mechanical tracking systems to follow the sun. The tracking mechanism maintains the cell at the proper tilt angle and azimuthal position under control from a photoelectric sun sensor. These tracking mechanisms are better used in areas of little ice and snow such as the southwest U.S. Gallium-arsenide cells are used because, although they are more expensive, they are capable of operating at efficiencies up to 21% when exposed to 1000 suns concentrators. One manufacturer Varion has developed a 1.25 cm diameter cell capable of producing 9W under a solar concentrator of 400 suns.

3.3.3. Cadmium Sulfide/Copper Sulfide Cells

Cadmium Sulfide (CdS) cells use two different materials to produce the PV effect. Its main advantage is that it can be manufactured in a thin film procedure which is inexpensive. Its main disadvantages are that its efficiency and lifetime are less than silicon.

3.3.4 Selenium Cells

Selenium cells was one of the first PV devices, appearing just before the development of the Silicon p-n junction. It has a lower efficiency than silicon. Its main use is in light measuring devices because its response peak is in the visible spectrum instead of the silicon which peaks in the infrared.

3.4 SOLAR RADIATION IN THE BATTLE HARBOUR REGION

3.4.1 Solar Radiation

Solar radiation is measured in S1 units by MJ/m^2 and in the old Imperial units by Langleys. In Newfoundland and Labrador there are only 2 sites with more than 20 years worth of solar radiation data, St. John's West and Goose Bay. In 1983 the Atmospheric Environment Service undertook a program to derive solar radiation statistics for selected sites across Canada. One such site is Battle Harbour as further explained later in the report.

Solar radiation is broken down into 2 subsets (1) Global Solar Radiation, and (2) Diffuse Solar Radiation. Global solar radiation by definition is the total incoming direct and diffuse short wave solar radiation received from the whole dome of the sky on a horizontal surface. Diffuse solar radiation by definition is the portion of the total incoming short wave solar radiation received on a horizontal surface that is shielded from the direct rays of the sun by means of a shade ring.

3.4.2 Direct Solar Radiation

Direct solar radiation is measured by a Campbell-Stokes recorder which burns a trace in the card below a glass sphere corresponding to the direct sunshine. This is then converted into MJ/m^2. In Newfoundland and Labrador there are 13 sites where the data has been collected. The closest site to the two coastal communities of interest is Goose Bay.

3.4.3 Other Sources of Solar Data

In 1982, C. Banfield at Memorial University developed a series of solar radiation tables for selected sites around the province using all available data. This report was produced to indicate the solar potential for sites outside the immediate data collection areas for the design of greenhouses, etc.

3.4.4 Data Requirements

For the purposes of this report the computer analysis requires that the global radiation be used in PV F-Chart. This is because the program modifies this radiation by certain empirical factors to generate the solar potential at a particular site. The solar radiation data for Battle Harbour is found in Appendix 2.0.

It is worthwhile to note that to truly assess the solar potential at a particular site solar radiation data should be collected for at least 1 year. However for examination of the system economics, this item can be set aside and historical weather data used.

3.4.5 PV Site Selection Factors

The placement of the solar cell array is affected by 2 factors:

(1) shading of the array from objects located in the front and to the side of the array, and

(2) row to row shading for PV arrays arranged in multiple rows.

The determination of array shading is an important part of site selection in the view of the sensitivity of array output to shadowing. Shadowing should be minimized especially during the hours of 0900 to 1500 solar time.

For row to row shading above 45° latitude the back rows of the solar cells will always be shaded during the winter months unless the rows are located on a slope or the rear rows are raised to create a slope.

3.4.5.1 Pinsent's Arm PV Array Site Considerations

Pinsent's Arm has a large open area to the northeast of the community as shown by location PV1-PA in Figure 3.1. However, an alternate site to this is location PV2-PA which is the side of the hill just southwest of the community. This will depend on the size of the array and whether 2 or more rows are required.

3.4.5.2 Norman Bay PV Array Site Considerations

The array of Norman Bay Figure 3.2 shows that there are 2 possible site locations for the array marked PV1-NB and PV2-NB. The first site has been chosen to take advantage of the natural slope to minimize row to row shading. The second site has been chosen to take advantage of its proximity to the houses. It would require a platform to raise the rear rows.

3.5 PHOTOVOLTAIC SYSTEM DESIGN

3.5.1 Introduction

A photovoltaic system can be used with batteries as a stand-alone system for a remote location or as part of the cycle charge system outlined in Section 2.2.

3.5.2 PV Stand-Alone Design

Solar Visions (1982) has provided preliminary assessment for the PV system design as follows by using a monthly output computation. This is used as the first generation input for the PV F-Chart computer program.

(1) The tilt angle is set at the Latitude for equinox, Latitude -15^0 for summer solstice and Latitude $+15^0$ for winter solstice.

(2) The month requiring the largest value of array area and storage capacity will determine the equipment size.

(3) The component sizing should be increased 10% to allow for equipment degradation with time.

(4) The battery capacity is the equivalent battery cell capacity to provide a 20 year system life divided by the allowable percent depth of discharge for the battery.

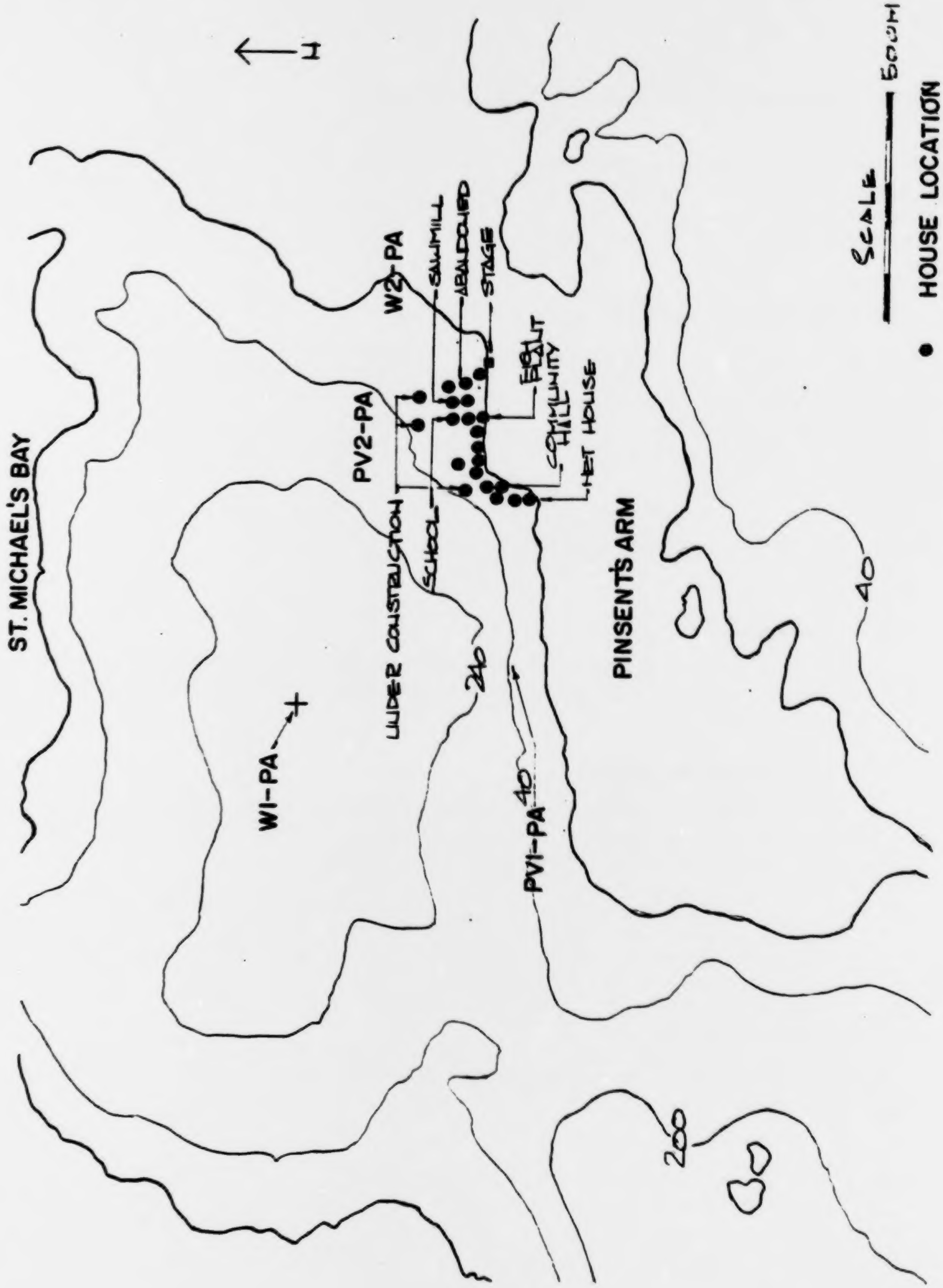

ST. MICHAEL'S BAY
PINSENT'S ARM
N
W2-PA
SAWMILL
ABANDONED
STAGE
FISH PLANT
COMMUNITY HALL
HOT HOUSE
PV2-PA
SCHOOL
UNDER CONSTRUCTION
W1-PA
PV1-PA
240
40
40
200
SCALE
500M.
● HOUSE LOCATION

FIGURE 3.1

MAP OF PINSENT'S ARM WITH PV AND WECS LOCATIONS

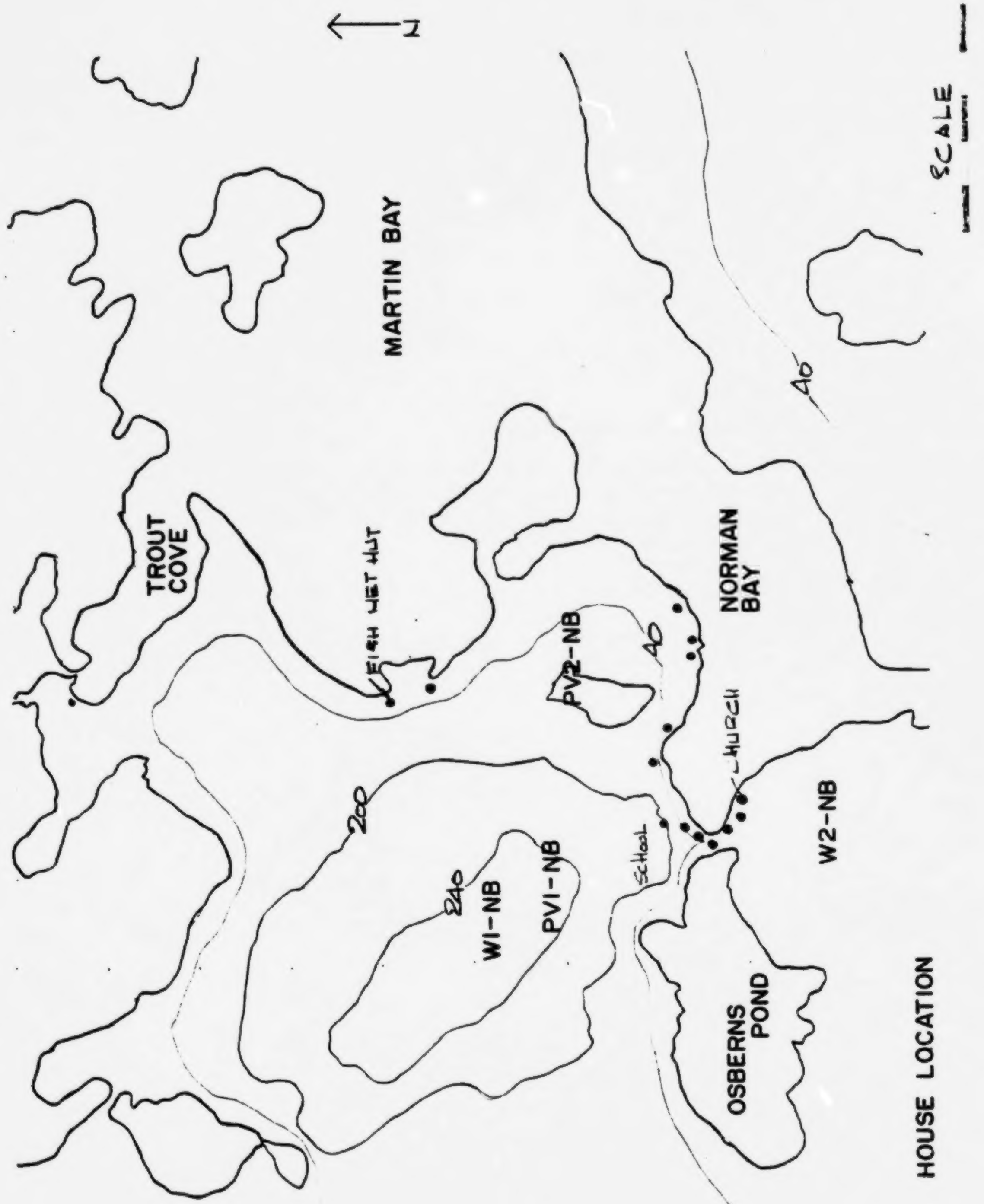

N
SCALE
500 M.
MARTIN BAY
TROUT COVE
FISH WET HUT
NORMAN BAY
40
PV2-NB
40
CHURCH
200
W2-NB
School
240
WI-NB
PVI-NB
OSBERNS POND
● HOUSE LOCATION

FIGURE 3.2

MAP OF NORMAN BAY WITH PV AND WECS LOCATIONS

3.5.2. PV Stand-Alone Design (Cont'd)

The array area can be estimated by determining the month when the lowest peak sunhours occurs and multiplying this figure by the rated peak output of the array to satisfy the average daily load. The peak draws of the system are covered by the battery capacity. The PV stand-alone system is therefore as follows:

TABLE 3.1
PV STAND-ALONE SYSTEM

Array Power	40.3 kWp
Array Size	526 m^2
Battery Capacity	20 days (5940 kWh) storage

The system design details and life cycle cost analysis are found in Section 5.4.

3.5.3 PV/Cycle Charge System Design

When the PV array is used as one of the renewable energy sources in the cycle charge system design it is optimized for summer usage to coincide with the maximum solar radiation available. This allows the following changes to be made in the PV system design:

(1) the peak array size drops to approximately one half of the stand-alone design, and
(2) the battery capacity drops to the minimum capacity required by the cycle charge system. Therefore the PV/cycle charge system is as follows:

TABLE 3.2
PV/CYCLE CHARGE SYSTEM

Array Power	16.13 kWp
Array Size	210 m^2
Battery Capacity	9 hrs (367 kWh) storage
Cycle Charge Genset	60 kW

For further life cycle cost details, see Section 5.3.2 - PV Cycle Charge.

4.0 WIND ENERGY CONVERSATION SYSTEMS TECHNOLOGY

4.1 INTRODUCTION

The use of wind as a source of energy is an old approach dating back some 2000 years to the Persian windmills. Until the birth of the industrial revolution and the advent of the steam engine, windmills ranked second only to wood as an energy source. (Cheremisinoff, 1978).

It has been estimated by the American Government that the total power capacity of the winds is in the order of 10" gigawatts (GW). This section of the report will briefly outline the types of wind machines available commercially, the wind potential in the study region, and the basic system design.

4.2 WIND ENERGY

The energy associated with wind is in the form of kinetic energy. The kinetic energy (E) per unit volume of moving air is expressed as

$$E = 1/2 \; C \; u^2 \qquad (2.1)$$

where u is the average linear wind speed and C is the density of air. The wind speed is proportional to the number of unit volumes arriving at the blades of the wind machine per unit of time. For a freely moving stream of air with a cross-sectional area A the amount of power associated with it is equal to the product of this area times the speed of the wind stream times its kinetic energy per unit volume. Therefore the wind power density P is defined as the power per unit cross-sectional area of the wind stream and is given by

$$P/A = 1/2 \; C \; u^3 \qquad (2.2)$$

A further application of these concepts is found in Section 4.5.

4.3 WIND MACHINE TYPES

Many types of wind energy conversion systems (WECS) have been designed and constructed over the course of windmill history. Today the most common machines are classified according to their axis of rotation relative to the earth's surface. The major categories of WECS are:

(1) Horizontal axis
(2) Vertical axis rotors.

4.3.1 Horizontal Axis Machines

The following paragraphs in this sub-section has been taken from Cheremisinoff (1978):

"Horizontal-axis rotors, often called head-on machines, are those devices in which the axis of rotation is parallel to the direction of the wind. These designs fall into the conventional type of windmills. These devices can either be lift or drag systems."

"Lift devices are preferred because they generally develop much higher force per unit area than direct drag devices. Furthermore, drag devices are usually not capable of moving faster than the wind velocity. Lifting surfaces, on the other hand, are capable of attaining high tip-to-wind speeds. This means higher power output-to-weight ratio which in turn favors the economics of such a system with a lower cost-to-power output ratio."

"Designs have been varied with the number of blades. Systems can range from one-bladed units equipped with a counterweight to multiblade systems having 50 or more blades (such as the U.S. multiblade windmill). The bending loads on the roots of the blades are often reduced by employing canted blades. Most horizontal-axis rotors are yaw-active, which means they will change position depending on the wind direction. For small units designed to yaw, a tail-vane is used. For larger systems, the yaw action is generally servo-operated."

"One class of horizontal-axis rotors is designed so that the blades rotate in front of the tower with respect to the wind direction. These are generally referred to as upwind rotors. Another variation, called downwind rotors, has blades rotating in back of the tower. Both types are usually equipped with flaps on the blades and pivot vanes mounted parallel to the blades to prevent the propeller from overspeeding in high winds or gusts and to manipulate the propeller sideways to the wind, respectively."

Commercial horizontal-axis WECS are available in the power levels that extend from 200 watts to 150,000 watts.

4.3.2 Vertical-Axis Rotor Systems

The following paragraphs in this sub-section has been taken from Cheremisinoff (1978):

"The first windmills were of the vertical-axis type; however, they were never incorporated in any large-scale operations like the horizontal-axis systems. The one major advantage that these systems have over the horizontal-axis units is that they do not have to be repositioned into the direction of oncoming wind as the wind stream direction changes. This advantage essentially reduces some of the complexity in design and at the same time reduces the gyro forces on the rotors that in the former systems cause stress on blades and other components when yawing."

4.3.2 Vertical-Axis Rotor System (Cont'd)

"In general, vertical-axis rotors are those machines which have their axis of rotation at right angles to both the earth's surface and the direction of the wind. Savonius rotors, which were invented and used in the 1920s and 1930s in Finland, are the most common design. The Savonius-type rotors generally employed S-shaped blades - a minimum of 2 curved blades in the shape of an S; up-to-date designs were multibladed units. The Savonius models, like most of the various types of vertical-axis systems, are primarily drag devices, although this design does actually provide some lift force. The main disadvantage of such arrangements is that they have relatively high starting torques in comparison to lift-type designs. Furthermore, they have a lower tip-to-wind speed ratio than the horizontal-axis lift systems, which means lower power outputs for a given rotor size and weight."

"The most promising competitor to the horizontal-axis designs is the Darrieus-type rotor. It was introduced in France by G.J.M. Darrieus in the 1920s. Its configuration consists of only two or three thin blades that rotate very rapidly. The speed of rotation of the Darrieus is primarily dependent on the machine's overall diameter. The Darrieus has relatively low starting torque but a high tip to wind speed ratio; three or four to one. Hence, these units can be almost as efficient as a horizontal-axis system." However, the majority of manufacturers in the power range required for the study produce Horizontal Axis WECS because of reliability considerations, therefore the selection of machinery will be limited to horizontal-axis WECS.

4.4 WIND ENERGY POTENTIAL IN THE BATTLE HARBOUR REGION

4.4.1 Introduction

It has been long recognized by Canadian government authorities that the Labrador coast has the highest wind potential in Canada. The Atmospheric Environment Service, Department of Environment has reduced the meteorological data for Battle Harbour, Labrador amongst other sites allowing computer analysis (DUST). The DUST simulation methodology has been described in Section 1.7.2.

4.4.2 Wind Site Selection Factors

In Section 2.4.2. it was shown that wind power varies as the cube of the wind speed. Therefore it is very important to have detailed information on the climatological distribution of wind speeds at each site under consideration.

4.4.2 Wind Site Selection Factors (Cont'd)

The general approach to evaluating a site includes:

(1) making a survey of all historical meteorological data for a particular region of interest,
(2) preparing and examining contour maps of the terrain,
(3) based on statistical analysis of average wind speeds, direction, environmental conditions, etc., narrowing the choice down to several potential sites,
(4) monitoring meteorological conditions at the most promising sites for a minimum of one year.

Similar to the solar radiation data collection, this report is an initial economic examination of the PV/WECS/cycle charge system. The last item in the general approach must be set aside until the actual specification of a WECS is begun.

As a first factor in wind site selection two important rules of thumb should be applied if possible.

Rule #1 The WECS should be located at least 150 meters from closest obstacle such as trees, buildings, etc.

Rule #2 The WECS should be located at least 10 meters above nearby obstacles.

These rules are applied at each site location i.e. Pinsent's Arm and Norman Bay to determine the optimum location of the WECS.

4.4.3 Pinsent's Arm WECS Site Considerations

Figure 3.1 is a map of Pinsent's Arm showing the relevant contours. From this map it can be seen that there is a hill 750 metres from the community which is 110 metres high, designated as location W1-PA. This would be a preferred location for the wind turbine because of the relatively clear access to the prevailing winds in the area. An alternate site location W2-PA although not quite as good due to of the shadowing effect of the hill would be just east of the community at this point.

4.4.4 Norman Bay WECS Site Consideration

Figure 3.2 is a map of Norman Bay showing a small hill 73 metres high just due north of the majority of the community as marked by location W1-NB. This site centrally located between the fish net repair building on Martin Bay and the rest of the community on Norman Bay is recommended. The alternate site for this community is the hill due south marked by W2-NB which is 36 metres high.

4.5 WIND ENERGY CONVERSION SYSTEM DESIGN

4.5.1 Introduction

The WECS can be used as stand alone battery system for a remote location or as part of the cycle charge system. The stand-alone system will be first discussed.

4.5.2 Wind Energy Conversion System Stand-Alone Design

Among the problems of a wind only type of installation are (1) determining the number and size of WECS and (2) the storage capacity (i.e. batteries) required. The solution to these two problems are not independent as some of the parameters affecting battery capacity are directly related to wind machine capacity.

The deciding factors of both wind machine size and storage capacity must be weighed with practicality, thus the equipment is selected to satisfy average power requirement of the community under average yearly wind conditions. If, for example, the storage capability must double due to an occurence of low wind, which happens only several times over twenty years, it is more practical for the community to live with an occasional low power period due to the high capital cost of batteries.

The minimum wind machine capacity must be such that enough energy can be extracted from operating wind periods to charge the batteries for a period of too low or too high wind speeds. This situation is probably the most extreme in the lowest wind energy month. The total swept area of the WECS must be such that enough energy can be extracted from the wind to meet the community consumption. WECS size is increased by a percentage to account for dumping of energy during a possible long high wind period during this month. Confidence of this WECS sizing relies on duration statistics for that month.

The storage capacity of the batteries is dependent on a number of factors. They must be able to (1) discharge at a rate to meet peak loads, (2) to be charged at the full power output of the WECS, (3) to meet community consumption during low wind periods, (4) to recover as much energy as is practical from long high wind periods, and (5) the necessity to offset the occurence of separate long low wind durations occuring close together. The WECS stand-alone design is therefore as follows:

TABLE 4.1
WECS STANDARD SYSTEM

Turbine Power	50 kW
Battery Capacity	4 days (1190 kWh) storage

The system design details and life cycle cost analysis are found in Section 5.5.

4.5.3 WECS/Cycle Charge Design

When the WECS is used as one of the renewable energy sources in the cycle charge system design it should be optimized for winter usage to coincide with the increased availability of wind energy. Similar to the PV/cycle charge design (1) the WECS size can be reduced to generate the average energy required over a typical 24 hour period and (2) the battery storage capacity drops to the minimum capacity required by the cycle charge system. Therefore the WECS/cycle charge system is as follows:

TABLE 4.2
WECS CYCLE CHARGE SYSTEM

Turbine Power	4 kW
Battery Capacity	9 hrs (367 kWh) storage
Cycle Charge Genset	60 kW

5.0 LIFE CYCLE COST ANALYSIS

5.1 COST ASSUMPTIONS

Costs for each system component were estimated individually using the Ontario Ministry of Energy photovoltaic report as its basis. These estimates are based on 1984 $ and adjusted to the Newfoundland/Labrador situations where appropriate. The detailed costs are presented for each separate application. For summary purposes, Table 5.1 shows selected individual component price trends.

The battery cost reduction in the optimistic scenario assumes that there will be a technological breakthrough allowing this dramatic price reduction. The photovoltaic prices assume that the U.S. price will go down. The Canadian cost of PV cells includes the exchange rate (1.30) and the duty (1.15).

TABLE 5.1
ALTERNATE ENERGY SYSTEM COMPONENTS
ASSUMED REAL PRICE BEHAVIOUR OVER STUDY PERIOD
PRICE PER PEAK WATT, 1984 $

Component	Year		
	1984	1985	1995
PV Array	9.71	5.80	N/A
Battery (Optimistic)	1.50	1.50	0.60
Battery (Realistic)	1.50	1.50	2.50

N/A - Not Applicable - no replacement anticipated at this time.

For each system cost, comparison between the standard diesel and completing alternative technologies is done using current dollars and assuming a general rate of inflation and the real cost projections in Table 5.1. The other cost assumptions are listed in Table 5.2 with the following explanations of each economic parameter:

(a) Consumer Price Index

The consumer price index was taken from the Ontario Ministry of Energy Department (August, 1984).

(b) Electricity Price Increase

The electricity price increase was taken from the Ontario of Ministry of Energy Department (August, 1984).

5.1 COST ASSUMPTIONS (Cont'd)

(c) Fuel Price Increase

The fuel price increase was taken as an average after fuel escalation rates for the next twenty years from 1983 to 2003 as outlined in the Newfoundland and Labrador Hydro Mary's Harbour Report (December, 1983).

(d) Labour/Maintenance Increases

The labour and maintenance escalation rates were taken as an average of the rates provided in the Mary's Harbour Report.

(e) Discount Rate

The discount rate was taken from the Ontario Ministry of Energy Report (August, 1984).

TABLE 5.2
ECONOMIC ASSUMPTIONS USED IN COST ANALYSIS

ITEM	YEARS 1985 - 2004
Consumer Price Index	7%*
Electricity Price Increase	7%*
Fuel Increases	5.47%**
Labour/Maintenance Increases	5.5%**
Discount Rate	12%**

* Taken from Ontario Ministry of Energy Price Outlook, Winter 1983.
**Taken as an average of rates used in the Mary's Harbour Report.

5.2 LEVELIZED COST ANALYSIS

The economic analysis to compute the cost per kilowatt-hour generated is similar to the Ontario Ministry Report. The real levelized cost of electricity is found by calculating the present value of the system cost which has been adjusted for the consumer price index (inflation) and the discount rate from Table 5.1. The factor used in the Present Worth Escalation Factor (PWEF) is defined as:

PWEF = (5.1)

where $n = 20$ years
$j = 7\%$
$i = 12\%$

PWEF = 12.82

5.2 LEVELIZED COST ANALYSIS (Cont'd)

Therefore the life cycle cost is the sum, in present value terms, of capital and operating costs associated with the system examined for a calculated quantity of electricity delivered.

The problem therefore, is to calculate the kilowatt-hour contribution of each competing technology and arrive at the system cost which produced this contribution.

5.3 STANDARD DIESEL GENSET TECHNOLOGY

As previously discussed the standard diesel system consists of 3 diesel sets rated at 40 kW, 25 kW and 12.5 kW respectively. The component costs are listed in Table 5.2.

The diesel gensets have variable costs such as fuel, operation and maintenance. Fuel costs have been given as $0.3187/litre for the 1984-1985 heating season. The utility has provided an additional data from Paradise River, Williams Harbour and Charlottetown so that the operation and maintenance costs can be calculated. Therefore, a standard diesel case has been developed which is

(1)	Diesel efficiency	1.75 kWh/litre of fuel
(2)	Diesel Fuel Cost	$0.16/kWh
(3)	Operation and Maintenance	$0.10/kWh
(4)	Labour Cost	$70,000 per annum

The life cycle cost summary is found in Table 5.3.

The labour component for a semi attended plant is made up of salaries and overheads for 2 full time diesel operators. It has been identified separately because, besides fuel savings over the life of the project, there is a strong case for promoting labour savings. This will be discussed further in Section 6.3.

The costs are based on Pinsent's Arm data. For Norman Bay, there would be an additional of $50,000 because the community is more spread out and would require more distribution lines. This cost is translated into an additional $0.125 per kilowatt-hour in all cases.

TABLE 5.3
STANDARD DIESEL GENSET
LIFE CYCLE COSTS

System Components	
Diesel	58,000
Fuel Storage	50,000
Diesel Building	40,000
A/C Distribution	95,000
Sub-total	$243,000
System Integration	
Design	18,000
Installation	5,000
Contingency	5,000
Transportation	9,900
Sub-total	$ 33,500
Standard Diesel Capital Cost 1984 $	277,500
Standard Diesel Capital Cost 1985 $	296,900
Fuel & Maintenance Costs	134,100
Total Life Cycle Cost (excluding operating costs) 1985 $	431,000
kWh provided	39450
Real Levelized Cost/kWh	
1985 $	0.85

5.4 CYCLE CHARGE TECHNOLOGY

Mechron Ltd. has provided a quotation for a 60 kW cycle charge system. This quotation includes the controls, storage hut, batteries and extra backup diesel. This configuration is kept for all the cycle charge cases.

5.4.1 Cycle Charge System

The cost summary for the cycle charge system is found in Table 5.4 and shows the cost per kilowatt-hour without the labour component. Provision has been made for markup by the local distributor.

TABLE 5.4
CYCLE CHARGE GENSET (60 KW)
LIFE CYCLE COSTS

System Components	Optimistic	Realistic
Controls/Diesel/Building	165,000	165,000
Batteries*	73,000	113,000
Fuel Tank	50,000	50,000
Foundation	5,000	5,000
A/C Distribution	95,000	95,000
Sub-Total	338,000	428,000
System Integration		
Design	25,000	25,000
Installation	10,000	10,000
Contigency	10,000	10,000
Transportation	10,000	10,000
Markup	66,000	66,000
Sub-Total	121,000	121,000
Cycle Charge Capital Costs 1984 $	459,000	549,000
Cycle Charge Capital Costs 1985 $	491,000	587,400
Maintenance Costs	46,400	58,700
Diesel Operating Costs**	53,700	53,700
Total Life Cycle Cost (excluding operating costs)1985$	591,100	699,800
kWh Provided	39,450	39,450
Real Levelized Cost/kWh 1985 $	1.17	1.38

*Batteries are replaced in the 10th year. The present value includes this additional cost.

**Fuel costs were calculated by taking 40% of the standard diesel fuel bill.

5.4.2 PV Cycle Charge System

The additional cost of the photovoltaic equipment has been added to the cycle charge costs and summarized in Tables 5.5. The installation costs have gone up to reflect the increased labour to install the arrays.

TABLE 5.5
PHOTOVOLTAIC/CYCLE CHARGE GENSET (16.13 KW)
LIFE CYCLE COSTS

System Components	Optimistic	Realistic
Array		
Modules	93,000	156,600
Structure	13,000	13,000
Sub-total	106,400	169,600
Cycle Charge Genset		
Controls/Diesel/Building	165,000	165,000
Batteries*	73,000	113,000
Fuel Tank	50,000	50,000
Foundation	5,000	5,000
A/C Distribution	95,000	95,000
Sub-total	338,000	428,000
System Integration		
Design	30,000	30,000
Installation	22,000	22,000
Contingency	10,000	10,000
Transportation	10,000	10,000
Markup	66,000	66,000
Sub-total	138,000	138,000
Life Cycle Capital Cost 1984 $	582,000	735,600
Life Cycle Capital Cost 1985 $	623,100	787,100
Maintenance Costs	61,000	82,000
Diesel Operating Costs	44,900	44,900
Total Life Cycle Costs (excluding operating costs) 1985 $	729,000	914,000
kWh Provided by PV	26,260	26,260
kWh Provided by Cycle Charge	13,190	13,190
Real Levelized Cost/kWh 1985 $	1.44	1.81

*Batteries are replaced in the 10th year. The present value includes this additional cost.

5.4.3 WECS Cycle Charge System

The additional cost of the wind energy equipment has been added to the cycle charge costs and summarized in the Table 5.6. The 4 kW turbine, with the lowest additional cost per kilowatt-hour, was chosen out of a selection of 2, 4, 8, and 10 kW units.

TABLE 5.6
WIND CYCLE CHARGE GENSET
LIFE CYCLE COSTS

System Components	Optimistic	Realistic
Wind Energy Conversion System Installed	18,500	18,500
Sub-total	18,500	18,500
Cycle Charge System		
Controls/Diesels/Building	165,000	165,000
Batteries*	73,000	113,000
Fuel Tank	50,000	50,000
Foundation	5,000	5,000
A/C Distribution	95,000	95,000
Sub-total	338,000	428,000
System Integration		
Design	25,000	25,000
Installation	10,000	10,000
Contingency	10,000	10,000
Transportation	10,000	10,000
Markup	66,000	66,000
Sub-total	121,000	121,000
Cycle Charge Capital Costs 1984 $	427,500	567,500
Cycle Charge Capital Costs 1985 $	511,000	607,200
Maintenance Costs	48,900	61,300
Diesel Operating Costs	94,400	94,400
Total Costs (excluding operating costs)1985$	654,300	762,900
kWh Provided by Wind System	11,700	11,700
kWh Provided by Cycle Charge	27,750	27,750
Real Levelized Cost/kWh 1985 $	1.29	1.51

*Batteries are replaced in the 10th year. The present value include this additional cost.

5.5 PV AND WECS TECHNOLOGIES

For comparison purposes the PV battery system has been included and summarized in Tables 5.7. Similarly the WECS system has been tabulated in Tables 5.8.

5.6 SUMMARY AND DISCUSSION

Table 5.9 summarizes the results for the various system simulations. Before the detailed discussion of results begins, a word of interpretation is required.

5.6.1 PV/Cycle Charge Interpretation

The kWh figures are net of the spillage which takes place when the PV system produces electricity that is unused because the load is met and batteries are fully charged. This spillage is identified as excess in the PV F-Chart output.

The computer model ignores several potentially important factors -

(1) Monthly values used - empirical calculations may be slightly off.
(2) Battery Efficiencies are yearly averages.
(3) Diesel component is not included directly because PV F-Chart does not have this capability. Therefore the closest figures are approximately the difference between the desired load and the PV component. In addition the diesel costs may be under estimated due to:

    (a) efficiency loss due to battery charging and
    (b) the neglect of diesel load efficiency.

5.6.2 Wind Energy Interpretation

The kWh figure used for life cycle analysis is the amount of wind energy which can reasonably be expected to be generated. Each calculation used the AES data in combination with the duration statistics (DUST) to determine available energy profiles. Additional energy savings may be realized by applying a probability factor that the peak loads occur during higher wind periods. These additional savings have not been included because the occurance of wind peaks in a remote community with a wind/no storage power system would be not only be unpredictable but also be unrealistic.

However, since this is the best tool currently available, these results should be considered as preliminary until a more sophisticated renewable/hybrid model becomes available.

TABLE 5.7
PHOTOVOLTAIC SYSTEM (40 KW)
LIFE CYCLE COSTS

System Components	Optimistic	Realistic
Array		
Modules	233,700	391,300
Structure	32,500	32,500
Sub-total	266,200	423,800
Balance of System		
Inverter	52,500	52,500
Batteries* (20 days storage)	1,871,100	2,425,600
Controls & Wiring	15,700	15,700
A/C Distribution	95,000	95,000
Sub-Total	2,034,300	2,588,800
System Integration**		
Design	122,500	122,500
Installation	28,800	28,800
Contingency	23,600	23,600
Transportation	33,000	33,000
Markup	125,800	125,800
Sub-total	333,700	333,700
Cycle Charge Capital Cost 1984 $	2,634,200	3,346,300
Cycle Charge Capital Cost 1985 $	2,818,600	3,580,500
Maintenance Costs	316,300	413,200
Total Life Cycle Costs (excluding operating costs) 1985 $	2,950,500	3,759,500
kWh Provided by PV	39,450	39,450
Real Levelized Cost/kWh 1985	5.83	7.43

* Batteries are replaced in the 10th year. The present value includes this additional cost. The battery prices are from local suppliers not Mechron and are therefore $250/kWh versus Mechron's $150/kWh.

**System Integration Figures are from Ontario Ministry of Energy Report.

TABLE 5.8
WIND ENERGY CONVERSION SYSTEM (50 KW)
LIFE CYCLE COSTS

System Components	Optimistic	Realistic
Turbine & Tower (50 kw)	87,600	87,600
Installation	20,000	20,000
Line from WECS to Village	70,000	70,000
Sub-total	177,600	177,600
Cycle Charge Genset		
Hut	30,000	30,000
Invertor	32,400	32,400
Batteries* (4 days storage)	220,200	486,000
Controls & Wiring	15,700	15,700
A/C Distribution	95,000	95,000
Sub-total	393,100	659,100
System Integration		
Design	26,000	20,000
Installation	10,000	10,000
Contingency	10,000	10,000
Transportation	10,000	10,000
Markup	27,000	27,000
Sub-total	83,000	83,000
Cycle Charge Capital Cost 1984 $	653,700	919,700
Cycle Charge Capital Cost 1985 $	699,500	984,100
Maintenance Costs	78,300	114,800
Total Life Cycle Costs (excluding operating costs) 1985 $	777,800	1,098,900
kWh Provided by WECS to community	39,450	39,450
kWh Provided by WECS in total	100,000	100,000
Real Levelized Cost/kWh 1985 $	1.54	2.17

*Batteries are replaced in the 10th year. The present value includes this additional cost. (See 5.7 battery costs explanation.)

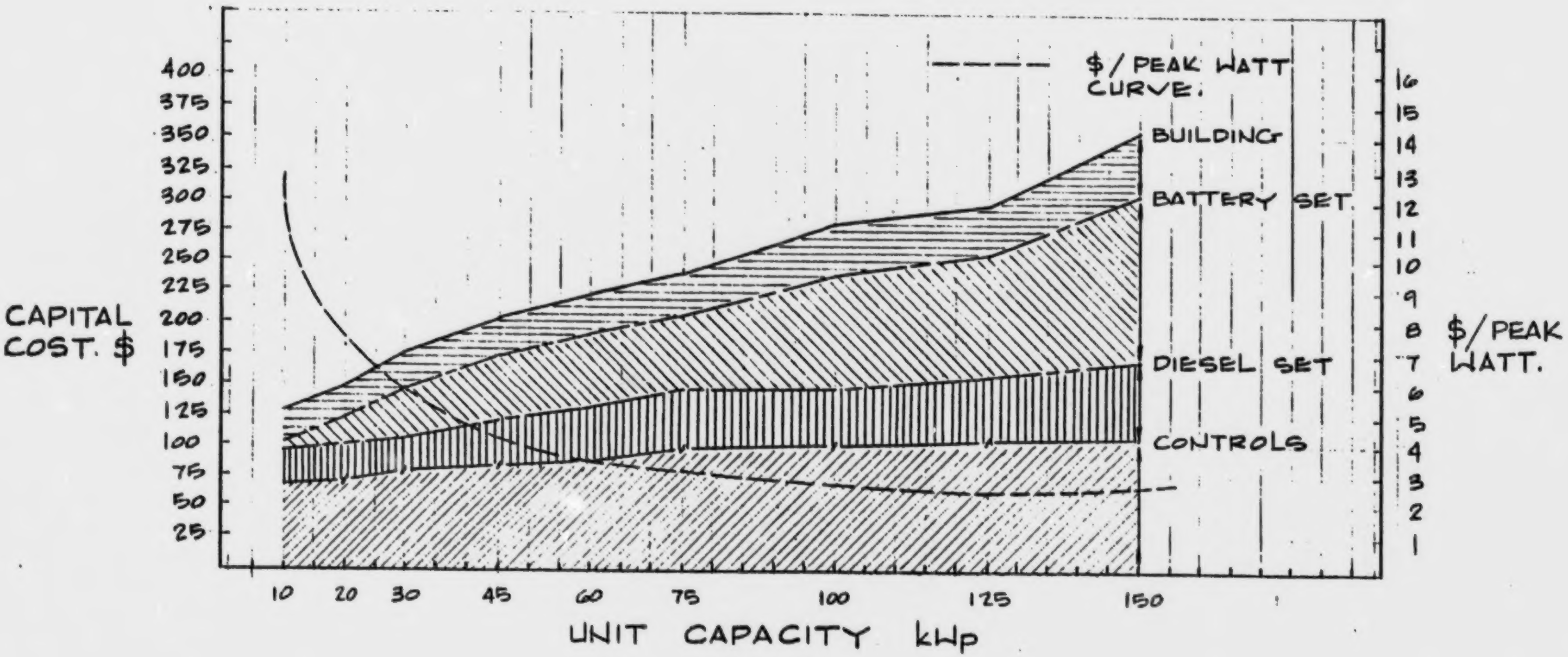
TABLE 5.9
SUMMARY OF LIFE CYCLE COST (1985 $)

System Type	Net Present Worth		$/kWh (Excluding Labour Cost)	
	Optimistic	Realistic	Optimistic	Realistic
Standard Diesel	431,000	431,000	0.85	0.85
Cycle Charge System	591,100	699,800	1.17	1.38
PV/Cycle Charge	729,000	914,000	1.44	1.81
WECS Cycle Charge	654,300	762,900	1.29	1.51
PV only	2,950,500	3,759,500	5.83	7.43
WECS only	777,800	1,098,900	1.54	2.17

5.6.3 Levelized Cost Discussion

From Table 5.9, it can be seen that the lowest alternative price per kilowatt-hour is the cycle charge system at $1.38 which is 62% more than the bas standard diesel system. Therefore at the present time, the alternative technologies are not cost effective for the proposed site.

The generated cost per peak kW for the village configuration is $3.20. Figure 5.1 presents the various capital costs of the cycle charge component and shows that the optimum plant capacity for cycle charge is 125 kW. This is 30% lower in cost than the unit specified at Pinsent's Arm.



CAPITAL COST OF CYCLE CHARGE COMPONENTS

FIG. 5.1

6.0 RECOMMENDATIONS AND CONCLUSIONS

6.1 SYSTEM MAINTENANCE

System maintenance for the alternative energy electric generation system is primarily concerned with

(1) Battery maintenance,
(2) Diesel maintenance,
(3) PV maintenance, and
(4) Wind turbine maintenance.

6.1.1 Battery Maintenance

The only data available on the question of battery maintenance is taken from the Newfoundland Telephone Four Mile Pond Cycle Charge Experiment. The Four Mile Pond site used a lead acid battery because of cost considerations. The actual battery chosen was the Gould NAX 2184 telecommunications battery which is not intended for deep cycling but will withstand a 10% daily discharge.

Battery maintenance consists of checking the specific gravity, the voltage loads and cleaning the cell covers at regular intervals. The telephone company measures these parameters quarterly each year. Gould recommends a complete record history be taken of the battery operation for the first year as a basis for comparison with subsequent readings to reflect possible operating problems and the need for corrective action.

The other main battery maintenance item is water addition due to (1) normal evaporation and (2) the conversion of water into hydrogen and oxygen. Water additions are usually scheduled prior to an equalized charge.

During the experiment the batteries were maintained as per the Gould recommended procedures. The main failure mode is the lateral growth of the cell's positive plate. The secondary failure mode is the shedding of active material due this growth. This leads to a loss of capacity and eventually the battery fails to meet its objectives for reserve time.

At the experiment site a patented miniature sonar unit was used to measure the lateral growth. It was found that the battery grew 0.37% and therefore was under the 5 to 10% lateral growth window at which point the battery can be considered to fail. During the experiment there was no loss of capacity and the battery met the telephone company's objective of five year service.

6.1.2 Diesel Maintenance

Diesel maintenance must be considered in light of the additional costs or benefits which may take place due to the introduction of the cycle charge system. From the Four Mile Pond experiment it was difficult to determine the extra diesel maintenance (if any) caused by the new equipment. The only problem agreed upon by the maintenance staff was the replacement of the starter motor. Besides that item, it was generally felt that the frequency of maintenance should be considerably less than at a prime site. In fact the present worth over 20 years has been predicted to be 1/2 of the standard diesel genset according to Newfoundland Telephone calculations.

6.1.3 PV Maintenance

Photovoltaic maintenance is quite simple and straight forward and consists of (1) keeping the arrays clean from dust, debris and snow and (2) periodic check of the electrical connections. This is the prime reason that PV arrays are becoming so attractive because they are inexpensive to maintain; that is unskilled labour can be used to perform the maintenance.

6.1.4 Wind Turbine Maintenance

Maintenance of a wind turbine system is more complex that the PV system and about the same as a diesel system. Included in Appendix 3.3 is an excerpt from the Jacobs Service Manual. Whenever there are moving parts, there is additional maintenance and there is also the added concern that the turbine is exposed to the most potentially destructive force of all, the very wind that drives it. This is why maintenance is critically important to a wind energy conversion system.

6.2 SYSTEM RELIABILITY

System reliability and maintainability is of critical importance to a utility. According to Newfoundland and Labrador Hydro their system are designed to have loss of load probabilities of 0.2 days/year. For diesel communities the system design is such that even in the event of the loss of the largest diesel the other two diesels will be able to meet the peak load.

For telecommunications work the system reliability is typically designed to 99.9989%. From historical data Transport Canada achieved system reliability of 99.997% for 97 sites over a 34 year period. An alternative energy electric generation system must be reliable enough to meet the utility's standards. Mechron Ltd. has provided data on their diesel system reliability and the mean time between failure (MTBF) is quoted to be 18,750 hours based on 97 sites and a mean time to repair for a single diesel of 5.62 hrs. If the cycle charge running system time is 29% of the average prime diesel plant (from Four Mile Pond Experiment) then the mean run time of one of the dual diesels is 1270 hrs/year. It is therefore expected the one year availability would be 187,500 hours or 5.625/0.00003. This time is exceeds the 20 year running life of the diesel set which is 2970 hr x 20 years = 59,000 hours.

6.2 SYSTEM RELIABILITY (Cont'd)

These figures are taken from a small 12.5 kW set and should be able to be extrapolated to the larger 60 kW gensets especially since a dual diesel set has been quoted for reliability.

Since the cycle charge system is the backbone of the alternative energy systems and the diesel are the electricity producers of last resort, the overall system reliability can be considered to be excellent especially in light of the fact that there are trained diesel mechanics available on site and twin diesels are integral to the cycle charge system design.

6.3 MANPOWER REQUIREMENTS

As previously mentioned one of the major costs in a standard diesel system is the labour component. If this can be reduced through the introduction of new technology then the cost savings to the utility are significant. This is discussed further in Section 6.4.3.

6.4 FUTURE TECHNOLOGY

The systems which have been just described are available now and are economic. However, two recent developments will enhance the adoption of these new technologies at an increased rate. They are:

(1) Remote Telemetry and
(2) Automatic Load Management.

6.4.1 Remote Telemetry

Transport Canada has recently (May 1984) called for proposals for a telemetry system which would remotely monitor a series of cycle charge power systems.

The purpose of this system is to provide supervisory control and data acquisition of a remote cycle charge system. It is to provide solicited-on-line information and control to the master control station operator. This system would also be typical for a standard prime power system installed in a remote location. The result will be better planned maintenance and the avoidance of shutdowns for remote sites. With more detailed information coming from a site about a problem it makes it much easier for the crew going in to fix problems to go better prepared.

6.4.1 Remote Telemetry (Cont'd)

The specification calls for the following:

(1) Status Panels.
(2) IBM PC personal computer with a 10 Megabyte hard disk drive.
(3) Auto dialing modems.
(4) Sensors and Transducers.

The parameters to be monitored include the following:

(1) Room Ambient Temp
(2) Outside temperature
(3) Batteries temperature
(4) Water Level of batteries
(5) Fuel Level
(6) Unit "A" on
(7) Unit "B" on
(8) Date
(9) Time
(10) Station Battery Voltage
(11) Station Battery Current Load
(12) "Start" battery voltage on unit "A"
(13) "Start" battery voltage on unit "B"
(14) "Start" battery current on unit "A"
(15) "Start" battery current on unit "B"
(16) Fan shutter on unit "A"
(17) Fan shutter on unit "B"
(18) Engine shutter on unit "A"
(19) Engine shutter on unit "B"
(20) No speed signal
(21) Low oil pressure
(22) Control fault

Parameters to be controlled include:

(1) Microprocessor reset
(2) Engine control reset for Unit "A"
(3) Engine control reset for Unit "B"
(4) Unit "B" preferred
(5) Start battery maintenance run.

A system similar to the above is already being developed at Newfoundland Telephone Co. Ltd. to monitor all its remote cycle charge telecommunication sites. Their system is even more advanced than the one just described.

6.4.2 Automatic Load Management

In the U.S. at this present time the utilities are examining the use of automatic load management to control loads within the household such as domestic hot water heaters and clothes dryers.

The adoption of this technology to the cycle charge/renewable systems would allow for the maximization of the renewable component of the system by controlling the peaks in the system to coincide with the maximum output of the renewable sources such as solar or wind. Therefore the cost per kilowatt-hour would drop for the renewable component of the system.

6.4.3 Manpower Reduction

One of the major costs in the operation of a standard diesel system is the labour component. This cost for Pinsent's Arm is $70,000 per year for 24 hour operation which adds another $1.77/kWh to the values given in Table 5.9. If this can be reduced through the introduction of new technology then the cost savings to the utility are significant.

At the present time the utility policy is to have at least 2 men manning each diesel plant to give 24 hour coverage. This is to ensure that in the event of an accident or illness that there is at least 1 man capable of operating the system.

There may be justification in the future for the reduction of one person at an alternative power generator site when

(1) the system can demonstrate reliability in an unmanned mode.
(2) the telemetry system for such generator schemes has been demonstrated to give adequate early warning to the single operator to allow for backup part procurement in remote locations.

As previously mentioned, Newfoundland Telephone Co. Ltd. is in the process of developing a remote telemetry system similar to the one described in Section 6.4.1, to monitor cycle charge systems at its Labrador sites. However, the time frame for the adoption of a single man system may be 10 to 20 years hence.

6.5 FINAL RECOMMENDATIONS

The results of the analysis show that:

(1) The renewable cycle charge combinations are not economically feasible at the present time because of high capital costs.
(2) The installation of the new cycle charge technology may reduce the fuel costs of 40 - 60% over a standard diesel genset installation.
(3) Pinsent's Arm is more economically viable over Norman Bay by a factor of approximately 2 to 1 because it is a continuously occupied while Norman Bay is occupied for only two-thirds of the year.

It is therefore recommended that an alternate location for the cycle charge diesel electric system be sought to

(1) establish the maximum fuel savings possible,
(2) establish the technical data base in the cases of (a) system reliability and (b) system maintenance.

The alternate location should have an existing diesel plant and power distribution system.

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DUST Statistical Interpretation

The duration statistics for Battle Harbour are presented in graphical form for all twelve months and for a range of wind speed ranges. The different wind speed ranges are required as typical of cut-in and cut-out speeds of several wind machines. the durations are interpreted as follows: The duration in hours is given on the horizontal axis. The corresponding vertical axis is a measure of the percent of durations that exceed that duration length.

For example, for January the speed range of less than seven (7) knots/hr. for the duration of fourteen hours is exceedingly only one percent of all durations which are less than seven knots/hr. or 99% of the time the wind speed less than 7 knots will be less than 14 hours in duration.

APPENDIX 1.0

COMMUNITY SERVICES PROFILE

PINSENT'S ARM

COMMUNITY: PINSENT'S ARM

STATUS: Unincorporated
LOCATION: Lat.: 52° 41'
Long.: 55° 54'

A DEMOGRAPHICS

Population (1984) : 51

Population Structure by Age and by Gender - 1984

```
     Male                   Age                 Female
8 7 6 5 4 3 2 1 0                          0 1 2 3 4 5 6 7 8

              |---|       55 - 64          |
                |-|       45 - 54          |-----|
              |---|       35 - 44          |-|
|---------------|       25 - 34          |---------------|
              |---|       20 - 24          |---|
              |---|       15 - 19          |---|
          |-------|       10 - 14          |-|
              |---|        5 -  9          |-----|
        |---------|        0 -  4          |-----|

Male Population: 28                        23 :Female Population
```

1984 RESIDENTIAL ENERGY PROFILE

	QUANTITY	ENERGY VAUE	COMMENTS
Fuel Wood	130 tonnes	1060	
Gasoline	1500 liters	240 GJ	For Snowmobile and Chainsaw while obtaining wood.
Diesel Fuel	5000 liters	260	For generating electricity for community use
Furnace Oil	6400 liters*	250 GJ	
TOTAL		1810 GJ	

*Teacher's Residence/School treated as one residence and is sole user of furnace oil in community.

B COMMUNITY SERVICES

Water

Source:

Lake: ____ River ____ Wells ____ Other _X_ Stream /Pond During Winter

Distribution

Pipe ____ Truck ____ Individual Systems ____ None _X_ Piped From Stream to Near the Community

Serving:

Government Buildings ____ Commercial Buildings ____ Residences ____ Standpipes ____

Treatment:

Sedimentation ____ Filtration ____ Chlorination ____

Fluoridation ____ None _X_

Sewage

Collection System:

Pipe ____ Truck ____ Individual Systems ____ None _X_

Serving:

Government Buildings ____ Commercial Buildings ____ Residences ____

Disposal:

Lagoon ____ Septic Tanks _X_ Treatment Plant ____ None _X_

Solid Waste Disposal

Garbage Collection Organized: Yes ____ No _X_

Landfille Site Utilized: Yes ____ No _X_

Other: ______________ Yes ____ No _X_

Police Protection

R.C.M.P.: Yes X No ___

Patrolled from: Mary's Harbour

Fire Protection Organized:

Organized: Yes ___ No X

Equipment: ___

C COMMUNITY FACILITIES

Health

Clinic in Community: Yes ___ No X

Size of Facility: ___

Staff: Doctors ___ Nurses ___

Other ___

Education

School located in community: Yes X No ___

Grades: 1 - 8

Size: N/A Classrooms: 1 Teachers: 2

Residential

(1) Number of occupied private dwellings: 11
(2) Number of Houses with sewer and water: NONE

(3) Housing Condition:

(4) Number of owned homes: 10
(5) Number of rented homes: 1
(6) Number of single detached homes: 10
(7) Number of single attached homes: 1
(8) Average number of persons per private household: 4, 6
(9) Dwellings heated by steam or hot water:
(10) Dwellings heated by hot air:
(11) Dwellings heated with stove or space heater:
(12) Dwellings heated by electric heat:
(13) Other:

Community/Institutional/Commercial/Industrial Buildings

Gov't Fish Handling Area	Not Heated/Cooled by Ice

D ECONOMIC ACTIVITIES

1. Fishing
2.
3.

E COMMUNICATION LINKS

	Yes	No	Comments
Post Office		X	Charlottetown
Television	X		CBC
Radio	X		CBC
Telephone	X		1 Radiophone/Citizen Band Radio
High Frequency Radio			

F TRANSPORTATION LINKS

Access to Community By Scheduled Services

	Carrier	Type
Air	LABAIR	To Charlottetown
Marine	CN Coastal Boat	As Scheduled
Bus	N/A	
Other	N/A	

Local Transportation

	Yes	No	Type
Boats	X		Fishing
Snowmobiles	X		
Cars		X	
Heavy Vehicles		X	
Other		X	

NORMAN BAY

COMMUNITY: NORMAN BAY

STATUS: Unincorporated
LOCATION: Lat.: 52° 56'
Long.: 55° 54'

A DEMOGRAPHICS

Population (1984) : 56

Population Structure by Age and by Gender - 1984

```
       Male                   Age                   Female
8 7 6 5 4 3 2 1 0                            0 1 2 3 4 5 6 7 8

               |-|          65 - 69          |
                 |          55 - 64          |-|

                 |          45 - 54          |-|

           |-----|          35 - 44          |---|

     |-----------|          25 - 34          |---------------|

           |-----|          20 - 24          |-|

         |-------|          15 - 19          |-|

   |-------------|          10 - 14          |---|

   |-------------|           5 -  9          |-----|

       |---------|           0 -  4          |---|

Male Population: 36                          20 :Female Population
```

1984 RESIDENTIAL ENERGY PROFILE

	QUANTITY	ENERGY VAUE (GJ)	COMMENTS
Fuel Wood	130 tonnes	1060	For cooking, space and water heating
Stove Oil	160 liters	6	For heating, only one household
Kerosene	2900 liters	126	For lighting
Gasoline	3800 liters	182	For snowmobile and chainsaw while obtaining wood
Gasoline	480 liters	23	For generator (only three in community)
Furnace Oil	6400 liters*	250	
TOTAL		1810 GJ	

*Two classroom school no information available of usage, estimated that it consumes similar quantities of fuel as the school/residence in Pinsent's Arm.

B COMMUNITY SERVICES

Water

Source:

Lake: X River X Wells ____ Other ____ Stream /Pond During Winter

Distribution

Pipe ____ Truck ____ Individual Systems ____ None X Piped From Stream to Near the Community

Serving:

Government Buildings ____ Commercial Buildings ____ Residences X Standpipes ____

Treatment:

Sedimentation ____ Filtration ____ Chlorination ____

Fluoridation ____ None X

Sewage

Collection System:

Pipe ____ Truck ____ Individual Systems ____ None X

Serving:

Government Buildings ____ Commercial Buildings ____ Residences X

Disposal:

Lagoon ____ Septic Tanks ____ Treatment Plant ____ None X

Solid Waste Disposal

Garbage Collection Organized: Yes ____ No X

Landfille Site Utilized: Yes ____ No X

Other: ________________ Yes ____ No X

Police Protection

R.C.M.P.: Yes X No ____

Patrolled from: Mary's Harbour

Fire Protection Organized:

Organized: Yes ____ No X

Equipment: ____________________

C COMMUNITY FACILITIES

Health

Clinic in Community: Yes ____ No X

Size of Facility: ____________________

Staff: Doctors ____ Nurses ______________

Other ______________________________

Education

School located in community: Yes X No ____

Grades: K - 9

Size: N/A Classrooms: 2 Teachers: 2

Residential

(1) Number of occupied private dwellings: 12
(2) Number of Houses with sewer and water: NONE
(3) Housing Condition: Poor
(4) Number of owned homes: 12
(5) Number of rented homes:
(6) Number of single detached homes: 12
(7) Number of single attached homes:
(8) Average number of persons per private household: 4, 7
(9) Dwellings heated by steam or hot water:
(10) Dwellings heated by hot air:
(11) Dwellings heated with stove or space heater: X
(12) Dwellings heated by electric heat:
(13) Other:

Community/Institutional/Commercial/Industrial Buildings

School - 2 Room

D ECONOMIC ACTIVITIES

1. Fishing Summer
2. Trapping Winter
3.

E COMMUNICATION LINKS

	Yes	No	Comments
Post Office		X	
Television	X		CBC - FOX HR.
Radio	X		CBC - FOX HR.
Telephone	X		A. Ward
High Frequency Radio		X	

F TRANSPORTATION LINKS

Access to Community By Scheduled Services

	Carrier	Type
Air	LABAIR	To Charlottetown
Marine	CN Coastal Boats	To nearby summer fishing communities
Bus	N/A	
Other	N/A	

Local Transportation

	Yes	No	Type
Boats	X		Longliner/open speed boat
Snowmobiles	X		
Cars		X	
Heavy Vehicles		X	
Other		X	

APPENDIX 2.0

ENVIRONMENT DATA FOR BATTLE HARBOUR

2.1 SOLAR RADIATION

ATMOSPHERIC ENVIRONMENT SERVICE

BATTLE HARBOUR (NFLD) (8500398)

MEAN MONTHLY GLOBAL SOLAR RADIATION
(RF1) FOR EACH HOUR (MJ / SQ METRE)
(TIMES ARE LOCAL APPARENT)

MOYENNE MENSUELLE DU RAYONNEMENT SOLAIRE GLOBAL
(RF1) POUR CHAQUE HEURE (MJ / METRE CARRE)
(TEMPS SONT LOCAL APPARENT)

HOUR HEURE	JAN JAN	FEB FEV	MAR MAR	APR AVR	MAY MAI	JUN JUIN	JUL JUIL	AUG AOU	SEP SEP	OCT OCT	NOV NOV	DEC DEC	
100													MEAN
													SD
200													MOYEN
													EC
300													MEAN
													SD
400													MOYEN
													EC
500					0.042	0.115	0.075	0.002					MEAN
					0.1042	0.0736	0.0586	0.0056					SD
600				0.069	0.290	0.386	0.334	0.150	0.006				MOYEN
				0.0775	0.1803	0.2159	0.1882	0.1153	0.0298				EC
700			0.089	0.392	0.642	0.713	0.659	0.466	0.186	0.005			MEAN
			0.1045	0.2153	0.3487	0.3954	0.3503	0.2647	0.1414	0.0212			SD
800		0.101	0.450	0.772	0.993	1.057	0.989	0.823	0.526	0.176	0.007		MOYEN
		0.1068	0.2483	0.3914	0.5101	0.5752	0.5376	0.4327	0.2909	0.1372	0.0775		EC
900	0.117	0.456	0.851	1.143	1.331	1.378	1.307	1.170	0.860	0.486	0.168	0.048	MEAN
	0.0893	0.2546	0.4266	0.5716	0.6604	0.7262	0.7071	0.5845	0.4454	0.2581	0.1200	0.0675	SD
1000	0.413	0.828	1.209	1.470	1.600	1.617	1.609	1.428	1.163	0.773	0.416	0.277	MOYEN
	0.2018	0.3851	0.5726	0.7246	0.7825	0.8303	0.8307	0.7085	0.5702	0.3780	0.2358	0.1428	EC
1100	0.668	1.089	1.460	1.681	1.829	1.799	1.827	1.633	1.349	0.978	0.611	0.485	MEAN
	0.3039	0.4870	0.6679	0.8298	0.8718	0.9020	0.9206	0.7970	0.6685	0.4634	0.3290	0.2385	SD
1200	0.801	1.232	1.583	1.811	1.939	1.902	1.952	1.738	1.464	1.067	0.708	0.603	MOYEN
	0.3590	0.5500	0.7204	0.8831	0.9201	0.9433	0.9396	0.8152	0.6801	0.5076	0.3804	0.2835	EC
1300	0.801	1.249	1.606	1.801	1.926	1.956	1.965	1.726	1.458	1.061	0.707	0.595	MEAN
	0.3562	0.5463	0.7379	0.8926	0.9171	0.9394	0.9001	0.7988	0.6786	0.5070	0.3720	0.2826	SD
1400	0.679	1.113	1.463	1.688	1.820	1.883	1.934	1.649	1.347	0.966	0.594	0.485	MOYEN
	0.3000	0.4753	0.6887	0.8310	0.8548	0.8866	0.8328	0.7630	0.6086	0.4400	0.3169	0.2337	EC
1500	0.434	0.817	1.198	1.482	1.619	1.683	1.713	1.451	1.135	0.760	0.402	0.277	MEAN
	0.2107	0.3772	0.5665	0.7013	0.7640	0.7960	0.7393	0.6895	0.5182	0.3569	0.2244	0.1406	SD
1600	0.128	0.465	0.844	1.164	1.329	1.422	1.439	1.171	0.839	0.475	0.168	0.045	MOYEN
	0.0947	0.2465	0.4131	0.5655	0.6588	0.6624	0.6443	0.5694	0.4038	0.2415	0.1232	0.0402	EC
1700		0.098	0.452	0.794	1.012	1.095	1.105	0.848	0.507	0.171	0.006		MEAN
		0.1042	0.2588	0.4000	0.5041	0.5241	0.4973	0.4208	0.2671	0.1315	0.0393		SD
1800			0.090	0.408	0.645	0.745	0.730	0.485	0.180	0.005			MOYEN
			0.1006	0.2218	0.3354	0.3652	0.3495	0.2689	0.1297	0.0131			EC
1900				0.082	0.291	0.409	0.381	0.160	0.006				MEAN
				0.1621	0.1743	0.2127	0.1935	0.1214	0.0453				SD
2000					0.041	0.122	0.083	0.002					MOYEN
					0.1016	0.0721	0.0617	0.0064					EC
2100													MEAN
													SD
2200													MOYEN
													EC
2300													MEAN
													SD
2400													MOYEN
													EC

BATTLE HARBOUR (NFLD) (8500398)

MEAN MONTHLY DIFFUSE SOLAR RADIATION
(RF2) FOR EACH HOUR (MJ / SQ METRE)
(TIMES ARE LOCAL APPARENT)

MOYENNE MENSUELLE DU RAYONNEMENT SOLAIRE DIFFUSE
(RF2) POUR CHAQUE HEURE (MJ / METRE CARRE)
(TEMPS SONT LOCAL APPARENT)

HOUR HEURE	JAN JAN	FEB FEV	MAR MAR	APR AVR	MAY MAI	JUN JUIN	JUL JUIL	AUG AOU	SEP SEP	OCT OCT	NOV NOV	DEC DEC	
100													MEAN MOYEN
													SD EC
200													MEAN MOYEN
													SD EC
300													MEAN MOYEN
													SD EC
400													MEAN MOYEN
													SD EC
500					0.030	0.073	0.047	0.001					MEAN MOYEN
					0.0975	0.0313	0.0246	0.0040					SD EC
600				0.047	0.183	0.235	0.195	0.086	0.005				MEAN MOYEN
				0.0429	0.0745	0.0800	0.0664	0.0430	0.0285				SD EC
700			0.058	0.256	0.395	0.413	0.369	0.253	0.102	0.004			MEAN MOYEN
			0.0622	0.1047	0.1527	0.1556	0.1397	0.0922	0.0547	0.0190			SD EC
800		0.053	0.263	0.485	0.600	0.594	0.532	0.428	0.281	0.108	0.007		MEAN MOYEN
		0.0469	0.1176	0.1976	0.2449	0.2370	0.2021	0.1587	0.1084	0.0712	0.0773		SD EC
900	0.069	0.228	0.474	0.693	0.780	0.762	0.687	0.602	0.447	0.279	0.111	0.033	MEAN MOYEN
	0.0402	0.1133	0.2147	0.2925	0.3050	0.3459	0.2802	0.2268	0.1800	0.1042	0.0648	0.0625	SD EC
1000	0.222	0.388	0.651	0.853	0.942	0.897	0.814	0.720	0.581	0.431	0.259	0.161	MEAN MOYEN
	0.0880	0.1822	0.3078	0.3837	0.3751	0.3937	0.3587	0.2788	0.2276	0.1606	0.1002	0.0497	SD EC
1100	0.334	0.497	0.776	0.951	1.048	1.005	0.897	0.795	0.673	0.530	0.372	0.272	MEAN MOYEN
	0.1421	0.2354	0.3669	0.4294	0.4248	0.4087	0.4042	0.2993	0.2712	0.1981	0.1426	0.0983	SD EC
1200	0.399	0.543	0.823	1.005	1.102	1.058	0.932	0.870	0.749	0.576	0.421	0.337	MEAN MOYEN
	0.1809	0.2763	0.3943	0.4658	0.4334	0.4498	0.4104	0.3445	0.3031	0.2202	0.1582	0.1238	SD EC
1300	0.396	0.571	0.836	1.014	1.108	1.073	0.949	0.856	0.741	0.577	0.417	0.337	MEAN MOYEN
	0.1796	0.2981	0.4231	0.4600	0.4318	0.4735	0.4105	0.3287	0.3046	0.2147	0.1562	0.1195	SD EC
1400	0.339	0.535	0.766	0.949	1.050	1.028	0.925	0.825	0.693	0.547	0.354	0.278	MEAN MOYEN
	0.1525	0.2731	0.3726	0.4206	0.4381	0.4468	0.4055	0.3372	0.2523	0.2085	0.1281	0.1039	SD EC
1500	0.225	0.412	0.646	0.879	0.940	0.922	0.833	0.731	0.593	0.440	0.248	0.164	MEAN MOYEN
	0.0961	0.2055	0.2977	0.3981	0.3676	0.4042	0.3481	0.2857	0.2121	0.1576	0.0886	0.0534	SD EC
1600	0.072	0.239	0.472	0.685	0.751	0.791	0.690	0.591	0.452	0.277	0.108	0.031	MEAN MOYEN
	0.0448	0.1210	0.2036	0.2970	0.2860	0.3097	0.2568	0.2203	0.1564	0.1086	0.0681	0.0301	SD EC
1700		0.055	0.265	0.472	0.577	0.621	0.539	0.430	0.277	0.102	0.005		MEAN MOYEN
		0.0486	0.1226	0.1884	0.2147	0.2553	0.2000	0.1598	0.1005	0.0591	0.0387		SD EC
1800			0.057	0.248	0.378	0.430	0.365	0.258	0.105	0.003			MEAN MOYEN
			0.0571	0.1040	0.1302	0.1617	0.1285	0.1001	0.0596	0.0078			SD EC
1900				0.058	0.177	0.238	0.199	0.092	0.005				MEAN MOYEN
				0.1512	0.0636	0.0820	0.0628	0.0539	0.0445				SD EC
2000					0.028	0.076	0.049	0.001					MEAN MOYEN
					0.0943	0.0327	0.0260	0.0045					SD EC
2100													MEAN MOYEN
													SD EC
2200													MEAN MOYEN
													SD EC
2300													MEAN MOYEN
													SD EC
2400													MEAN MOYEN
													SD EC

BATTLE HARBOUR (NFLD) (8500398)

MEAN MONTHLY DIRECT SOLAR RADIATION
(RF1-RF2) FOR EACH HOUR (MJ / SQ METRE)
(TIMES ARE LOCAL APPARENT)

MOYENNE MENSUELLE DU RAYONNEMENT SOLAIRE DIRECT
(RF1-RF2) POUR CHAQUE HEURE (MJ / METRE CARRE)
(TEMPS SONT LOCAL APPARENT)

HOUR HEURE	JAN JAN	FEB FEV	MAR MAR	APR AVR	MAY MAI	JUN JUIN	JUL JUIL	AUG AOU	SEP SEP	OCT OCT	NOV NOV	DEC DEC	
100													MEAN
													SD
200													MOYEN
													EC
300													MEAN
													SD
400													MOYEN
													EC
500					0.012	0.042	0.028	0.000					MEAN
					0.0257	0.0563	0.0399	0.0017					SD
600				0.022	0.107	0.151	0.139	0.064	0.001				MOYEN
				0.0473	0.1551	0.2071	0.1738	0.0891	0.0049				EC
700			0.032	0.136	0.248	0.301	0.290	0.213	0.084	0.001			MEAN
			0.0634	0.2102	0.3380	0.3975	0.3448	0.2548	0.1072	0.0051			SD
800		0.047	0.187	0.287	0.394	0.462	0.457	0.395	0.244	0.068	0.001		MOYEN
		0.0715	0.2407	0.4241	0.5369	0.5862	0.5435	0.4496	0.2779	0.0969	0.0035		EC
900	0.048	0.228	0.377	0.449	0.551	0.616	0.620	0.567	0.413	0.207	0.057	0.015	MEAN
	0.0632	0.2374	0.4529	0.6285	0.7080	0.7733	0.7233	0.6350	0.4609	0.2477	0.0822	0.0192	SD
1000	0.191	0.440	0.559	0.617	0.658	0.720	0.795	0.708	0.581	0.341	0.157	0.116	MOYEN
	0.1939	0.4064	0.6402	0.8095	0.8593	0.8973	0.8737	0.7818	0.6103	0.3950	0.2084	0.1291	EC
1100	0.334	0.593	0.684	0.731	0.781	0.794	0.931	0.838	0.676	0.447	0.239	0.213	MEAN
	0.3115	0.5391	0.7625	0.9546	0.9700	0.9779	0.9700	0.8799	0.7210	0.5175	0.3106	0.2295	SD
1200	0.401	0.690	0.760	0.806	0.837	0.844	1.020	0.868	0.715	0.491	0.287	0.265	MOYEN
	0.3772	0.6113	0.8494	1.0230	1.0342	1.0229	0.9978	0.8950	0.7318	0.5652	0.3668	0.2853	EC
1300	0.406	0.677	0.770	0.787	0.818	0.884	1.017	0.869	0.717	0.484	0.291	0.258	MEAN
	0.3781	0.6016	0.8403	1.0106	1.0240	1.0044	0.9865	0.8684	0.7256	0.5431	0.3629	0.2824	SD
1400	0.340	0.578	0.697	0.739	0.769	0.855	1.009	0.824	0.654	0.419	0.240	0.207	MOYEN
	0.3202	0.5187	0.7648	0.9253	0.9620	0.9477	0.9431	0.8136	0.6531	0.4707	0.3033	0.2284	EC
1500	0.209	0.406	0.552	0.603	0.679	0.761	0.881	0.720	0.542	0.320	0.155	0.113	MEAN
	0.2038	0.3897	0.6172	0.7865	0.8544	0.8639	0.8110	0.7357	0.5488	0.3682	0.2055	0.1278	SD
1600	0.056	0.226	0.373	0.479	0.578	0.632	0.749	0.580	0.386	0.198	0.060	0.014	MOYEN
	0.0667	0.2241	0.4359	0.6310	0.7168	0.7033	0.6964	0.5825	0.4038	0.2312	0.0869	0.0188	EC
1700		0.042	0.187	0.322	0.435	0.474	0.566	0.418	0.229	0.069	0.001		MEAN
		0.0678	0.2296	0.4177	0.5500	0.5481	0.5272	0.4271	0.2462	0.0981	0.0034		SD
1800			0.032	0.160	0.267	0.315	0.366	0.227	0.075	0.002			MOYEN
			0.0597	0.2113	0.3476	0.3733	0.3564	0.2506	0.0921	0.0056			EC
1900				0.024	0.114	0.171	0.182	0.069	0.001				MEAN
				0.0446	0.1581	0.2011	0.1801	0.0873	0.0046				SD
2000					0.012	0.046	0.034	0.001					MOYEN
					0.0259	0.0534	0.0416	0.0021					EC
2100													MEAN
													SD
2200													MOYEN
													EC
2300													MEAN
													SD
2400													MOYEN
													EC

BATTLE HARBOUR (NFLD) (8500398)

MEAN DAILY GLOBAL SOLAR RADIATION ON A SLOPED SURFACE (MJ / SQ METRE)
MOYENNE JOURNALIERE DU RAYONNEMENT SOLAIRE GLOBAL SUR UNE SURFACE INCLINE (MJ / METRE CARRE)

TILT INCL	AZM AZM	JAN JAN	FEB FEV	MAR MAR	APR AVR	MAY MAI	JUN JUIN	JUL JUIL	AUG AOU	SEP SEP	OCT OCT	NOV NOV	DEC DEC	ANNUAL ANNUEL	
0	0	4.040	7.448	11.286	14.755	17.350	18.283	18.103	14.899	11.026	6.921	3.787	2.814	10.903	MEAN
		1.7913	3.2971	4.9600	6.4805	7.3064	7.6945	7.1762	6.2787	4.7738	3.0431	1.9414	1.2935	7.6095	SD
30	0	1.653	2.775	6.117	10.881	14.340	15.647	14.830	10.970	6.503	3.268	1.940	1.344	7.541	MOYEN
		0.7301	1.3894	2.2385	3.2153	4.8122	5.6560	5.0111	3.5826	2.0055	1.2108	0.6796	0.4514	6.1562	EC
60	0	1.798	3.092	5.320	7.772	9.750	10.577	9.112	6.268	4.095	2.955	1.906	1.397	5.344	MEAN
		0.5976	1.1145	1.7229	2.1831	2.3439	2.8255	2.2899	1.6208	1.3067	0.9606	0.5731	0.3769	3.5825	SD
90	0	1.996	3.527	5.694	7.665	8.301	7.974	6.768	4.970	3.464	2.665	1.861	1.468	4.698	MOYEN
		0.6013	1.0914	1.5386	2.0228	1.9951	2.0866	1.6463	1.1390	0.8722	0.7638	0.6044	0.4257	2.7840	EC
30	270	4.232	7.493	11.163	14.457	16.630	17.370	17.442	14.190	10.471	6.722	3.802	2.851	10.577	MEAN
		2.0214	3.4013	5.0763	6.5051	7.0894	7.3038	6.7903	6.0061	4.5306	3.0397	2.0467	1.4093	7.2865	SD
60	270	4.422	7.600	10.834	13.580	14.928	15.128	15.185	12.412	9.304	6.272	3.735	2.926	9.697	MOYEN
		2.3210	3.7256	5.3237	6.5457	6.7643	6.6296	6.2259	5.5901	4.2934	3.0991	2.2188	1.6357	6.6104	EC
90	270	4.234	7.140	9.896	12.048	12.353	11.825	11.663	9.659	7.391	5.272	3.371	2.779	8.134	MEAN
		2.3230	3.6373	5.0657	6.0565	5.7204	5.2626	4.9490	4.5472	3.5818	2.7767	2.1429	1.6617	5.4511	SD
30	225	7.172	11.065	13.864	16.184	17.654	18.017	18.317	15.705	12.584	8.938	5.663	5.001	12.513	MOYEN
		4.3747	6.0415	7.4333	8.2572	8.0109	7.8808	7.4822	7.1849	6.2153	5.0351	4.0465	3.5099	8.0160	EC
60	225	8.923	12.732	14.514	15.732	15.925	15.528	15.893	14.134	12.067	9.367	6.528	6.242	12.289	MEAN
		5.9802	7.5614	8.5803	8.7054	7.5035	6.8588	6.6072	6.8268	6.4765	5.9357	5.2686	4.9057	7.7062	SD
90	225	8.844	12.086	13.068	13.517	12.590	11.416	11.449	10.604	9.563	8.140	6.179	6.205	10.289	MOYEN
		6.1004	7.3491	7.9049	7.5520	5.7510	4.7337	4.6073	5.1545	5.3174	5.4389	5.2325	5.0641	6.4188	EC
30	180	8.506	12.765	15.045	16.707	17.792	17.976	18.155	16.082	13.522	9.992	6.545	6.006	13.252	MEAN
		5.4810	7.3735	8.5162	8.8943	8.2295	7.9691	7.6797	7.5906	7.0591	6.0391	5.0070	4.4975	8.3593	SD
60	180	11.228	15.606	16.288	16.249	15.737	15.000	15.183	14.331	13.325	11.101	8.048	7.982	13.320	MOYEN
		7.8925	9.8059	10.1756	9.3367	7.3557	6.4697	6.4120	7.0613	7.5769	7.5873	6.9259	6.6124	8.3811	EC
90	180	11.476	15.211	14.694	13.469	11.672	10.106	9.922	10.051	10.484	9.950	7.893	8.214	11.067	MEAN
		8.2782	9.7744	9.3392	7.5943	4.8941	3.6242	3.6903	4.7392	6.1136	7.1680	7.1002	7.0295	7.2287	SD
30	135	7.063	11.162	13.857	15.998	17.524	17.831	17.702	15.587	12.742	9.025	5.661	5.035	12.430	MOYEN
		4.3233	6.2452	7.5592	8.3710	8.2336	8.1310	7.8426	7.4652	6.6143	5.2251	4.0711	3.5385	8.1090	EC
60	135	8.735	12.895	14.507	15.471	15.747	15.261	15.035	13.972	12.316	9.517	6.525	6.301	12.178	MEAN
		5.8889	7.8845	8.7620	8.8867	7.8168	7.2117	7.1363	7.2476	7.0837	6.2617	5.3110	4.9483	7.8937	SD
90	135	8.632	12.271	13.060	13.279	12.448	11.175	10.729	10.466	9.819	8.306	6.178	6.274	10.202	MOYEN
		5.9994	7.6958	8.0812	7.7403	6.0361	5.0269	5.0882	5.5602	5.9278	5.8011	5.2865	5.1115	6.6262	EC
30	90	4.125	7.609	11.150	14.218	16.446	17.090	16.551	14.027	10.673	6.828	3.802	2.889	10.457	MEAN
		1.9885	3.6548	5.2423	6.6685	7.3651	7.6976	7.3074	6.4035	5.0454	3.2500	2.0851	1.4571	7.3596	SD
60	90	4.270	7.756	10.811	13.262	14.698	14.728	14.000	12.202	9.580	6.412	3.733	2.979	9.536	MOYEN
		2.2745	4.0419	5.5296	6.7661	7.0541	7.1533	6.8769	6.1120	4.9707	3.3663	2.2715	1.6878	6.7278	EC
90	90	4.079	7.288	9.884	11.743	12.147	11.492	10.643	9.471	7.643	5.396	3.368	2.828	7.994	MEAN
		2.2749	3.9291	5.2540	6.2388	5.9377	5.6963	5.4365	4.9719	4.1820	3.0183	2.1930	1.7080	5.5647	SD

BATTLE HARBOUR (NFLD) (8500398)

MEAN DAILY SKY DIFFUSE SOLAR RADIATION ON A SLOPED SURFACE (MJ / SQ METRE)
MOYENNE JOURNALIERE DU RAYONNEMENT DIFFUSE PAR LE CIEL SUR UNE SURFACE INCLINE (MJ / METRE CARRE)

TILT INCL	AZM AZM	JAN JAN	FEB FEV	MAR MAR	APR AVR	MAY MAI	JUN JUIN	JUL JUIL	AUG AOU	SEP SEP	OCT OCT	NOV NOV	DEC DEC	ANNUAL ANNUEL	
0	0	2.056	3.521	6.086	8.594	10.090	10.215	9.019	7.538	5.706	3.874	2.300	1.612	5.891	MEAN
		0.7524	1.4249	2.2218	2.8434	2.9136	3.0700	2.5848	2.0415	1.6863	1.1652	0.7166	0.4625	3.6679	SD
30	0	1.493	2.481	4.803	7.423	9.007	9.231	8.029	6.522	4.668	3.045	1.822	1.237	4.989	MOYEN
		0.7435	1.4211	2.2788	2.7867	2.7306	2.8535	2.3864	1.9534	1.6417	1.2339	0.6886	0.4619	3.4614	EC
60	0	1.200	1.994	3.709	5.532	6.698	6.916	5.866	4.728	3.488	2.434	1.464	0.994	3.758	MEAN
		0.5975	1.1421	1.8718	2.4057	2.3242	2.3597	1.9794	1.6838	1.3593	0.9920	0.5533	0.3712	2.6382	SD
90	0	0.800	1.329	2.472	3.671	4.403	4.503	3.818	3.117	2.320	1.622	0.975	0.662	2.478	MOYEN
		0.3982	0.7611	1.2475	1.6115	1.5669	1.5965	1.3404	1.1294	0.9058	0.6610	0.3688	0.2473	1.7399	EC
30	270	1.970	3.344	5.724	8.057	9.402	9.543	8.461	7.060	5.338	3.636	2.168	1.521	5.525	MEAN
		0.6908	1.2931	2.0475	2.6350	2.6774	2.7924	2.3273	1.8474	1.5333	1.0821	0.6665	0.4267	3.3955	SD
60	270	1.683	2.827	4.719	6.564	7.600	7.721	6.873	5.749	4.367	3.002	1.800	1.277	4.521	MOYEN
		0.5602	1.0203	1.6325	2.1055	2.1395	2.2317	1.8474	1.4708	1.2199	0.8695	0.5521	0.3540	2.7152	EC
90	270	1.210	2.001	3.248	4.455	5.105	5.181	4.633	3.896	2.982	2.068	1.251	0.901	3.081	MEAN
		0.3944	0.6805	1.0900	1.4017	1.4303	1.4902	1.2316	0.9850	0.8176	0.5872	0.3915	0.2569	1.8057	SD
30	225	2.519	3.985	6.208	8.356	9.589	9.653	8.609	7.305	5.687	4.018	2.522	1.935	5.870	MOYEN
		0.8572	1.3962	2.0707	2.6264	2.7012	2.8226	2.3707	1.8640	1.5760	1.1002	0.8271	0.6317	3.3199	EC
60	225	2.522	3.749	5.377	6.934	7.786	7.790	6.993	6.028	4.827	3.534	2.331	1.916	4.985	MEAN
		0.9711	1.3027	1.7453	2.1226	2.1645	2.2519	1.8669	1.4850	1.3055	0.9835	0.8991	0.7962	2.5963	SD
90	225	2.069	2.893	3.815	4.708	5.156	5.113	4.601	4.052	3.347	2.563	1.783	1.561	3.473	MOYEN
		0.9155	1.0557	1.2511	1.4268	1.4334	1.4919	1.2422	0.9815	0.9010	0.7697	0.8124	0.7853	1.6709	EC
30	180	2.767	4.281	6.414	8.442	9.625	9.638	8.585	7.357	5.837	4.200	2.694	2.125	6.001	MEAN
		0.9895	1.5105	2.1162	2.6459	2.7487	2.8830	2.4460	1.9150	1.6358	1.1532	0.9546	0.7762	3.2883	SD
60	180	2.952	4.250	5.685	7.014	7.768	7.686	6.879	6.047	5.025	3.835	2.627	2.246	5.169	MOYEN
		1.2642	1.5871	1.8643	2.1612	2.2240	2.3178	1.9762	1.5499	1.4077	1.1447	1.1735	1.0834	2.5469	EC
90	180	2.560	3.437	4.095	4.686	5.008	4.877	4.348	3.949	3.489	2.877	2.118	1.943	3.615	MEAN
		1.2741	1.4165	1.3902	1.4530	1.4784	1.5431	1.3106	1.0154	0.9865	0.9847	1.1444	1.1279	1.6283	SD
30	135	2.501	3.981	6.193	8.313	9.585	9.603	8.511	7.265	5.697	4.033	2.531	1.941	5.851	MOYEN
		0.8679	1.4504	2.1049	2.6655	2.7797	2.8495	2.5174	1.9670	1.6502	1.1257	0.8497	0.6457	3.3429	EC
60	135	2.491	3.742	5.354	6.873	7.780	7.715	6.855	5.970	4.841	3.560	2.347	1.927	4.958	MEAN
		0.9769	1.3923	1.7932	2.1815	2.2786	2.4256	2.0941	1.6398	1.4232	1.0391	0.9393	0.8145	2.6348	SD
90	135	2.034	2.885	3.792	4.650	5.153	5.047	4.485	3.999	3.362	2.590	1.801	1.574	3.449	MOYEN
		0.9138	1.1470	1.2831	1.4805	1.5320	1.6349	1.4203	1.1250	1.0216	0.8356	0.8568	0.8025	1.7119	EC
30	90	1.954	3.339	5.704	8.002	9.396	9.469	8.318	7.006	5.350	3.652	2.178	1.528	5.498	MEAN
		0.7132	1.3511	2.0939	2.6860	2.7815	2.9754	2.5322	1.9835	1.6215	1.0952	0.6856	0.4444	3.4220	SD
60	90	1.659	2.820	4.692	6.488	7.594	7.616	6.683	5.676	4.384	3.024	1.814	1.287	4.484	MOYEN
		0.5876	1.0992	1.6930	2.1723	2.2754	2.4709	2.1172	1.6514	1.3427	0.8886	0.5800	0.3767	2.7507	EC
90	90	1.185	1.996	3.226	4.387	5.100	5.096	4.469	3.835	3.001	2.090	1.264	0.910	3.050	MEAN
		0.4149	0.7535	1.1467	1.4585	1.5364	1.6965	1.4503	1.1344	0.9273	0.6097	0.4192	0.2774	1.8368	SD

BATTLE HARBOUR (NFLD) (8500398)

MEAN DAILY DIRECT SOLAR RADIATION ON A SLOPED SURFACE (MJ / SQ METRE)
MOYENNE JOURNALIERE DU RAYONNEMENT SOLAIRE DIRECT SUR UNE SURFACE INCLINE (MJ / METRE CARRE)

TILT INCL	AZM AZM	JAN JAN	FEB FEV	MAR MAR	APR AVR	MAY MAI	JUN JUIN	JUL JUIL	AUG AOU	SEP SEP	OCT OCT	NOV NOV	DEC DEC	ANNUAL ANNUEL	
0	0	1.985	3.927	5.210	6.161	7.260	8.068	9.084	7.360	5.320	3.046	1.487	1.201	5.014	MEAN
		1.7854	3.4068	5.4016	7.2125	7.9517	8.0021	7.4968	6.5653	4.8417	3.1588	1.7779	1.2467	6.0630	SD
30	0	0.001	0.001	0.884	2.943	4.905	6.109	6.555	4.250	1.683	0.086	0.001	0.001	2.297	MOYEN
		0.0009	0.0010	1.3316	3.5035	5.3463	5.8943	5.3108	3.8247	1.7247	0.2153	0.0010	0.0010	4.0419	EC
60	0	0.001	0.002	0.003	0.313	1.450	2.513	2.327	0.797	0.041	0.002	0.001	0.001	0.624	MEAN
		0.0011	0.0011	0.0055	0.4690	1.7099	2.3365	1.9186	0.8234	0.0792	0.0011	0.0012	0.0012	1.3833	SD
90	0	0.002	0.002	0.003	0.137	0.692	1.174	1.110	0.363	0.008	0.002	0.002	0.002	0.293	MOYEN
		0.0011	0.0013	0.0015	0.2289	0.8543	1.1108	0.9483	0.3755	0.0192	0.0014	0.0013	0.0012	0.6642	EC
30	270	2.103	3.856	5.009	5.884	6.801	7.522	8.736	6.931	4.983	2.948	1.517	1.223	4.797	MEAN
		1.9208	3.3710	5.2310	6.8643	7.5014	7.5029	7.0614	6.1961	4.5228	3.0591	1.8167	1.3035	5.7313	SD
60	270	2.142	3.675	4.506	5.088	5.726	6.260	7.393	5.918	4.370	2.749	1.494	1.247	4.217	MOYEN
		1.9729	3.2560	4.7787	6.0201	6.5170	6.3679	6.0785	5.4136	4.0355	2.8749	1.7942	1.3520	4.9704	EC
90	270	1.828	2.943	3.428	3.734	4.042	4.347	5.190	4.274	3.272	2.162	1.235	1.072	3.129	MEAN
		1.6897	2.6332	3.6935	4.4782	4.7551	4.5183	4.3781	3.9980	3.0677	2.2895	1.4894	1.1727	3.6411	SD
30	225	4.494	6.786	7.226	7.313	7.637	8.059	9.463	8.202	6.745	4.782	3.023	2.959	6.387	MOYEN
		3.9648	5.7308	7.3986	8.4995	8.3669	8.0587	7.6966	7.2845	6.0633	4.8611	3.5245	3.0728	6.7938	EC
60	225	5.803	7.885	7.529	6.870	6.536	6.590	7.980	7.361	6.673	5.312	3.755	3.923	6.343	MEAN
		5.1073	6.6264	7.7179	8.0094	7.2302	6.6570	6.4800	6.5801	6.0099	5.3900	4.3617	4.0827	6.4409	SD
90	225	5.579	6.997	6.032	4.950	4.227	4.006	5.009	5.062	5.079	4.535	3.511	3.838	4.892	MOYEN
		4.9072	5.8725	6.2195	5.8108	4.7601	4.0892	4.1020	4.5794	4.6170	4.6063	4.0708	4.0021	4.9396	EC
30	180	5.579	8.190	8.200	7.750	7.740	8.032	9.324	8.526	7.534	5.653	3.733	3.773	6.995	MEAN
		4.8979	6.8733	8.3642	9.0885	8.5490	8.1121	7.8092	7.6352	6.8116	5.7300	4.3173	3.8917	7.2624	SD
60	180	7.678	10.258	8.994	7.307	6.367	6.166	7.385	7.540	7.731	6.745	4.979	5.334	7.189	MOYEN
		6.7127	8.5376	9.1349	8.5980	7.0854	6.3078	6.2448	6.7906	6.9928	6.8029	5.7190	5.4956	7.2455	EC
90	180	7.721	9.578	7.378	4.925	3.458	2.932	3.733	4.612	5.858	6.030	4.891	5.466	5.527	MEAN
		6.7326	7.9303	7.4927	5.8471	3.9067	3.0565	3.2022	4.2165	5.3320	6.0723	5.5939	5.6269	5.8969	SD
30	135	4.403	6.888	7.234	7.170	7.511	7.923	8.947	8.123	6.894	4.853	3.012	2.987	6.324	MOYEN
		3.9032	5.8666	7.4922	8.5722	8.4612	8.1327	7.8079	7.4426	6.3805	5.0027	3.5220	3.0842	6.8662	EC
60	135	5.647	8.055	7.543	6.670	6.365	6.398	7.260	7.258	6.907	5.436	3.737	3.972	6.260	MEAN
		5.0080	6.8539	7.8631	8.1327	7.3696	6.7895	6.6738	6.8369	6.5093	5.6346	4.3597	4.1020	6.5893	SD
90	135	5.403	7.189	6.047	4.771	4.088	3.831	4.404	4.977	5.321	4.673	3.492	3.894	4.828	MOYEN
		4.8014	6.1176	6.3627	5.9413	4.8659	4.2151	4.2810	4.8323	5.1205	4.8755	4.0734	4.0241	5.1055	EC
30	90	2.012	3.978	5.015	5.701	6.623	7.315	7.988	6.823	5.173	3.037	1.507	1.253	4.705	MEAN
		1.8533	3.5181	5.3431	6.9599	7.5943	7.6214	7.2097	6.4078	4.9243	3.2224	1.8178	1.3156	5.7884	SD
60	90	2.013	3.839	4.510	4.846	5.501	5.965	6.399	5.782	4.628	2.868	1.477	1.290	4.094	MOYEN
		1.8928	3.4419	4.9222	6.1567	6.5781	6.5699	6.2857	5.7105	4.5670	3.0765	1.7963	1.3644	5.0611	EC
90	90	1.699	3.095	3.437	3.498	3.841	4.099	4.334	4.147	3.506	2.264	1.220	1.112	3.020	MEAN
		1.6214	2.8002	3.8224	4.5806	4.7426	4.7253	4.5183	4.2406	3.5341	2.4485	1.4894	1.1814	3.7226	SD

GLOBAL SOLAR RADIATION (MJ/M^2) INCIDENT ON A HORIZONTAL SURFACE AND ON THREE SOUTH-FACING TILTED SURFACES

RAYONNEMENT SOLAIRE GLOBAL (MJ/M^2) SUR UNE SURFACE HORIZONTALE ET SUR TROIS SURFACES INCLINEES, ORIENTEES AU SUD

BATTLE HARBOUR (NFLD/TN) LATITUDE 52 DEG 15 MIN LONGITUDE 55 DEG 36 MIN PERIOD/PERIODE 1967-1976

DAILY RADIATION: MEAN AND STANDARD DEVIATION/RAYONNEMENT QUOTIDIEN: MOYEN ET ECART TYPE

TILT ANGLE INCLINAISON	JAN JAN	FEB FEV	MAR MAR	APR AVR	MAY MAI	JUN JUIN	JUL JUIL	AUG AOUT	SEPT SEPT	OCT OCT	NOV NOV	DEC DEC	ANNUAL ANNUEL	
0 DEG.	4.040	7.448	11.296	14.755	17.350	18.283	18.103	14.899	11.026	6.821	3.787	2.814	10.907	MEAN
	1.794	3.303	4.968	6.492	7.319	7.708	7.189	6.289	4.782	3.048	1.845	1.296	7.606	S.D.
LATITUDE	10.743	15.166	16.239	16.609	16.510	16.012	16.236	15.068	13.644	11.030	7.810	7.625	13.546	MOYEN
	7.457	9.412	9.993	9.455	7.782	7.041	6.927	7.403	7.648	7.379	6.594	6.223	8.483	EC.T.
LAT.+15 DEG	11.529	15.819	16.159	15.768	14.876	13.909	14.038	13.481	12.862	11.028	8.168	8.209	12.970	MEAN
	8.199	10.055	10.223	9.119	6.870	5.855	5.849	6.649	7.412	7.684	7.150	6.893	8.200	S.D.
90 DEG.	11.476	15.211	14.693	13.469	11.670	10.101	9.922	10.051	10.483	9.948	7.893	8.214	11.071	MOYEN
	8.292	9.792	9.354	7.605	4.902	3.629	3.696	4.747	6.124	7.180	7.112	7.041	7.225	EC.T.

9 AM TO 3 PM RADIATION: MEAN AND STANDARD DEVIATION/RAYONNEMENT DE 9 H A 15 H: MOYEN ET ECART TYPE

TILT ANGLE INCLINAISON	JAN JAN	FEB FEV	MAR MAR	APR AVR	MAY MAI	JUN JUIN	JUL JUIL	AUG AOUT	SEPT SEPT	OCT OCT	NOV NOV	DEC DEC	ANNUAL ANNUEL	
0 DEG.	3.795	6.329	8.520	9.932	10.733	10.840	11.001	9.624	7.916	5.603	3.437	2.721	7.541	MEAN
	1.648	2.715	3.737	4.544	4.693	4.856	4.595	4.189	3.450	2.456	1.755	1.254	4.614	S.D.
LATITUDE	9.730	12.455	12.293	11.703	11.038	10.479	10.944	10.462	10.014	8.726	6.859	7.258	10.151	MOYEN
	6.658	7.640	7.683	7.167	5.826	5.307	5.210	5.561	5.790	5.916	5.803	5.906	6.472	EC.T.
LAT.+15 DEG	10.407	12.833	12.231	11.197	10.089	9.287	9.684	9.517	9.480	8.685	7.145	7.802	9.855	MEAN
	7.304	8.141	7.865	6.998	5.300	4.608	4.578	5.121	5.645	6.142	6.275	6.534	6.491	S.D.
90 DEG.	10.318	12.364	11.111	9.639	7.957	6.801	6.970	7.252	7.776	7.779	6.868	7.792	8.533	MOYEN
	7.362	7.893	7.193	5.936	3.881	2.991	3.050	3.801	4.702	5.704	6.216	6.663	5.935	EC.T.

RATIO OF 9 AM TO 3 PM RADIATION TO DAILY RADIATION: MEAN AND STANDARD DEVIATION
RAPPORT DU RAYONNEMENT DE 9 H A 15 H AU RAYONNEMENT QUOTIDIEN: MOYEN ET ECART TYPE

TILT ANGLE INCLINAISON	JAN JAN	FEB FEV	MAR MAR	APR AVR	MAY MAI	JUN JUIN	JUL JUIL	AUG AOUT	SEPT SEPT	OCT OCT	NOV NOV	DEC DEC	ANNUAL ANNUEL	
0 DEG.	.943	.854	.753	.668	.616	.587	.602	.643	.717	.810	.908	.967	.756	MEAN
	.026	.040	.050	.053	.053	.061	.057	.058	.047	.044	.047	.038	.141	S.D.
LATITUDE	.916	.826	.750	.686	.651	.634	.656	.678	.725	.789	.879	.953	.762	MOYEN
	.046	.059	.061	.065	.060	.072	.066	.066	.056	.059	.067	.045	.122	EC.T.
LAT.+15 DEG	.913	.822	.749	.689	.659	.645	.669	.687	.727	.785	.875	.952	.764	MEAN
	.049	.063	.063	.066	.062	.075	.069	.068	.057	.063	.071	.047	.119	S.D.
90 DEG.	.910	.818	.749	.693	.663	.652	.681	.700	.731	.780	.870	.950	.766	MOYEN
	.051	.066	.063	.065	.063	.075	.072	.068	.057	.066	.076	.048	.116	EC.T.

DAILY GLOBAL SOLAR RADIATION (MJ/M^2) INCIDENT ON A HORIZONTAL SURFACE

RAYONNEMENT SOLAIRE GLOBAL QUOTIDIEN (MJ/M^2) SUR UNE SURFACE HORIZONTALE

BATTLE HARBOUR (NFLD/TN) LATITUDE 52 DEG 15 MIN LONGITUDE 55 DEG 38 MIN PERIOD/PERIODE 1967-1976

MONTH MOIS	NO. OF OBS D'OBS	RADIATION / RAYONNEMENT MINIMUM MINIMAL	MEAN MOYEN	MAXIMUM MAXIMAL	ST.DEV. EC.TYPE	PROBABILITY (PERCENT) OF LESS RADIATION THAN THE INDICATED AMOUNT POURCENTAGE PROBABLE DE RAYONNEMENT MOINDRE QUE LA QUANTITE INDIQUEE 10%	20%	30%	40%	50%	60%	70%	80%	90%
JAN	310	.598	4.040	7.555	1.7943	1.626	2.031	2.621	3.530	4.424	4.763	5.192	5.712	6.522
FEB/FEV	283	1.578	7.448	14.077	3.3031	2.893	3.777	5.135	6.618	7.818	8.528	9.543	10.689	12.033
MAR	310	3.067	11.296	21.767	4.9682	4.855	6.160	7.652	9.112	11.044	13.342	14.673	16.117	18.225
APR/AVR	300	4.180	14.755	28.871	6.4918	6.556	8.149	9.896	11.789	13.746	16.119	18.950	21.955	24.397
MAY/MAI	310	4.984	17.350	32.441	7.3191	8.302	9.940	12.277	13.919	16.486	18.603	21.382	25.264	28.430
JUN/JUIN	300	5.999	18.283	32.846	7.7083	8.168	10.168	12.718	15.437	17.821	20.478	22.963	26.934	29.760
JUL/JUIL	310	5.550	18.103	32.019	7.1889	7.961	10.590	13.162	15.876	18.517	20.823	23.100	25.521	27.462
AUG/AOUT	310	3.878	14.899	27.831	6.2895	6.532	8.267	10.308	12.570	14.602	16.551	18.996	21.525	23.428
SEPT	300	2.852	11.026	21.926	4.7820	4.497	6.057	7.400	8.807	11.062	12.811	14.567	15.703	17.309
OCT	310	1.337	6.921	15.303	3.0483	2.949	4.149	4.900	5.638	6.413	7.481	8.553	9.621	11.443
NOV	300	.955	3.787	8.793	1.9448	1.459	1.925	2.485	2.905	3.330	3.905	4.959	5.694	6.650
DEC	310	.701	2.814	5.175	1.2956	1.093	1.487	1.804	2.145	2.772	3.435	3.884	4.217	4.426
ANNUAL ANNUEL	3653	.598	10.907	32.846	7.6063	2.542	4.157	5.398	7.091	8.766	11.267	14.083	17.574	22.721

2.2 Wind Statistics

BATTLE HARBOUR LDR, NFLD/TN

WIND SUMMARY
ANALYSIS PERIOD: 1967 JA to/a 1976 DE :PERIODE D'ANALYSE
SUMMAIRE DU VENT

LATITUDE: 52°15'N
LONGITUDE: 55°36'W/O
ELEVATION: 9 m

	JA	FE	MR	AL	MA	JN	JL	AU	SE	OC	NO	DE	AN
MEAN AIR TEMPERATURE (°C) / TEMPERATURE MOYENNE DE L'AIR	-11.4	-10.8	-6.8	-2.4	1.4	5.2	9.6	10.8	8.3	3.5	-0.6	-7.2	-0.0
MEAN AIR PRESSURE (kPa) / PRESSION MOYENNE DE L'AIR	100.50	100.66	100.75	101.02	101.24	101.11	101.02	100.98	101.17	101.15	100.91	100.80	100.94
MEAN WIND SPEED (km/h) / VITESSE MOYENNE DU VENT	28.4	28.2	28.9	25.2	23.3	22.7	20.6	21.7	23.3	26.8	28.5	30.7	25.7

WIND DIRECTION FREQUENCY (hours/month) FREQUENCE DES DIRECTIONS DU VENT (heures/mois)

		JA	FE	MR	AL	MA	JN	JL	AU	SE	OC	NO	DE	AN
N		52	46	105	122	113	83	41	79	62	83	57	56	899
NNE		19	24	46	65	68	65	47	54	40	34	36	17	514
NE		13	17	32	29	40	45	27	24	22	21	23	16	309
ENE		12	14	23	22	19	23	21	19	16	15	16	14	214
E		9	12	16	32	20	21	17	19	15	13	15	21	211
ESE		10	10	14	19	16	14	13	16	12	13	14	17	168
SE		11	17	13	23	26	27	24	34	24	23	23	20	266
SSE		15	21	15	31	43	41	46	48	35	31	30	20	376
S		33	39	52	71	115	110	141	122	103	69	78	56	989
SSW	SSO	21	36	51	48	75	102	140	94	85	57	44	37	789
SW	SO	31	48	43	24	24	45	56	35	33	42	52	28	463
WSW	OSO	45	64	45	20	17	24	37	36	53	59	63	33	497
W	O	125	92	69	44	24	19	29	30	65	81	84	105	768
WNW	ONO	131	82	54	31	20	11	13	30	42	54	62	120	652
NW	NO	131	92	84	47	36	26	21	28	44	61	56	101	727
NNW	NNO	76	52	68	63	53	31	25	33	37	69	60	73	641
CALM	CALME	8	13	12	28	35	33	45	41	34	19	8	9	284

WIND DIRECTION FREQUENCY (% of time) FREQUENCE DES DIRECTIONS DU VENT (% du temps)

		JA	FE	MR	AL	MA	JN	JL	AU	SE	OC	NO	DE	AN
N		7.0	6.8	14.1	16.9	15.2	11.6	5.6	10.6	8.6	11.1	7.9	7.6	10.3
NNE		2.5	3.5	6.2	9.0	9.1	9.0	6.3	7.3	5.6	4.5	5.0	2.3	5.9
NE		1.7	2.4	4.4	4.1	5.4	6.2	3.7	3.2	3.0	2.9	3.2	2.2	3.5
ENE		1.7	2.1	3.1	3.0	2.5	3.2	2.8	2.6	2.2	2.0	2.3	1.8	2.4
E		1.2	1.8	2.2	4.4	2.7	2.9	2.3	2.6	2.1	1.7	2.1	2.8	2.4
ESE		1.4	1.5	1.9	2.7	2.1	2.0	1.7	2.2	1.6	1.7	1.9	2.2	1.9
SE		1.5	2.5	1.8	3.2	3.5	3.7	3.3	4.5	3.3	3.1	3.2	2.7	3.0
SSE		2.0	3.1	2.0	4.4	5.7	5.7	6.2	6.5	4.8	4.2	4.2	2.7	4.3
S		4.4	5.7	7.0	9.9	15.5	15.2	18.9	16.4	14.3	9.3	10.9	7.6	11.3
SSW	SSO	2.8	5.3	6.9	6.7	10.0	14.1	18.8	12.7	11.7	7.6	6.1	5.0	9.0
SW	SO	4.2	7.1	5.8	3.3	3.2	6.3	7.6	4.8	4.6	5.7	7.2	3.8	5.3
WSW	OSO	6.1	9.5	6.1	2.8	2.3	3.3	5.0	4.8	7.3	7.9	8.7	4.4	5.7
W	O	16.9	13.6	9.3	6.2	3.3	2.7	4.0	4.0	9.0	10.8	11.7	14.1	8.8
WNW	ONO	17.6	12.1	7.2	4.3	2.8	1.6	1.7	4.1	5.9	7.3	8.6	16.1	7.4
NW	NO	17.6	13.5	11.3	6.5	4.8	3.7	2.8	3.8	6.1	8.2	7.7	13.6	8.3
NNW	NNO	10.2	7.7	9.1	8.7	7.2	4.3	3.4	4.5	5.1	9.3	8.3	9.9	7.3
CALM	CALME	1.1	1.9	1.7	3.9	4.7	4.6	6.0	5.5	4.7	2.5	1.1	1.2	3.2

BATTLE HARBOUR LOR, NFLD/TN

WIND SUMMARY
ANALYSIS PERIOD: 1967 JA to/a 1976 DE :PERIODE D'ANALYSE
SUMMAIRE DU VENT

LATITUDE: 52°15'N
LONGITUDE: 55°36'W/O
ELEVATION: 9 m

MEAN WIND SPEED (km/h) — VITESSE MOYENNE DU VENT (km/h)

DIRECTION:		JA	FE	MR	AL	MA	JN	JL	AU	SE	OC	NO	DE	AN
N		35	37	38	34	32	30	23	28	31	33	35	39	33
NNE		40	40	37	31	27	29	26	27	29	34	39	37	31
NE		36	31	27	23	27	21	20	20	23	30	30	34	26
ENE		24	26	22	23	20	17	16	17	21	26	32	31	22
E		26	26	23	18	18	14	13	13	18	24	26	33	20
ESE		34	28	24	17	16	15	14	17	18	27	29	32	22
SE		34	32	27	19	17	16	16	22	23	29	33	34	24
SSE		32	34	25	20	19	20	20	21	24	28	29	35	24
S		32	31	29	22	22	23	23	23	24	26	28	34	25
SSW	SSO	30	29	31	26	23	25	25	25	26	27	28	31	26
SW	SO	32	31	32	27	24	24	21	23	25	25	29	29	27
WSW	OSO	25	28	28	25	27	24	25	25	25	25	25	28	26
W	O	24	24	23	20	20	21	21	19	20	22	23	27	23
WNW	ONO	27	24	24	25	24	18	16	19	20	23	27	27	25
NW	NO	28	26	29	26	23	26	18	21	25	29	29	31	27
NNW	NNO	30	31	30	33	28	28	23	23	26	32	31	32	30

	JA	FE	MR	AL	MA	JN	JL	AU	SE	OC	NO	DE	AN
MEAN WIND SPEED FROM ALL DIRECTIONS (km/h) — VITESSE MOYENNE DU VENT POUR TOUTES LES DIRECTIONS	28.4	28.2	28.9	25.2	23.3	22.7	20.6	21.7	23.3	26.8	28.5	30.7	25.7
EFFECTIVE MEAN WIND SPEED** (km/h) — ***VITESSE MOYENNE EFFECTIVE DU VENT	34.6	35.5	35.9	32.0	29.2	28.6	25.6	26.5	28.2	32.5	34.1	36.4	32.0

** The EFFECTIVE MEAN WIND SPEED is the cube root of the mean cubed wind speed.
*** La VITESSE MOYENNE EFFECTIVE DU VENT est la racine cubique de la moyenne au cube de la vitesse du vent.

MEAN DIRECTED WIND POWER (W/m²) — PUISSANCE MOYENNE DU VENT SELON LA DIRECTION (W/m²)

DIRECTION:		JA	FE	MR	AL	MA	JN	JL	AU	SE	OC	NO	DE	AN
N		1120	1307	1425	868	693	623	283	429	608	722	967	1346	865
NNE		1558	2242	1326	671	393	563	347	341	447	812	1289	1253	776
NE		1154	934	438	315	440	238	191	169	248	652	481	858	439
ENE		312	466	259	290	219	121	90	118	183	522	728	588	301
E		472	403	291	135	152	60	45	61	180	308	436	826	262
ESE		878	486	314	106	99	64	55	142	126	475	533	661	308
SE		909	685	387	176	124	96	93	228	279	609	806	1013	401
SSE		801	884	363	197	146	173	175	212	299	515	524	858	354
S		632	669	481	244	229	264	236	238	284	392	456	778	346
SSW	SSO	555	549	592	372	267	326	313	309	324	418	449	603	379
SW	SO	890	805	785	438	383	319	243	280	334	368	569	681	504
WSW	OSO	399	566	429	378	430	317	313	339	324	301	326	573	391
W	O	332	332	254	200	200	180	190	127	168	238	254	447	279
WNW	ONO	459	282	296	340	362	118	84	143	180	297	478	450	355
NW	NO	507	418	544	491	310	431	123	224	333	475	529	622	469
NNW	NNO	638	803	645	797	529	456	277	265	370	731	563	686	609

	JA	FE	MR	AL	MA	JN	JL	AU	SE	OC	NO	DE	AN
MEAN WIND POWER FROM ALL DIRECTIONS (W/m²) — PUISSANCE MOYENNE DU VENT POUR TOUTES LES DIRECTIONS	587	652	648	454	343	317	222	247	301	468	544	678	453

BATTLE HARBOUR LOR, NFLD/TN

WIND SUMMARY
ANALYSIS PERIOD: 1967 JA to/a 1976 DE :PERIODE D'ANALYSE
SUMMAIRE DU VENT

LATITUDE: 52°15'N
LONGITUDE: 55°36'W/O
ELEVATION: 9 m

MEAN DIRECTED WIND ENERGY (MJ/m^2) — ENERGIE MOYENNE DU VENT SELON LA DIRECTION (MJ/m^2)

DIRECTION:		JA	FE	MR	AL	MA	JN	JL	AU	SE	OC	NO	DE	AN
N		210	216	536	381	283	187	42	121	136	215	198	274	2798
NNE		105	194	221	156	96	132	58	67	65	98	166	79	1437
NE		54	56	51	33	64	38	19	14	19	50	39	50	488
ENE		14	24	21	23	15	10	7	8	10	28	43	29	231
E		15	17	17	15	11	4	3	4	10	14	24	63	198
ESE		33	18	16	7	6	3	3	8	5	22	26	39	186
SE		36	43	19	15	12	9	8	28	24	51	67	73	383
SSE		42	66	19	22	22	25	29	37	37	58	58	63	479
S		75	93	90	63	95	104	119	105	105	97	129	157	1234
SSW	SSO	42	71	109	64	72	119	158	105	99	86	71	81	1076
SW	SO	100	139	121	38	33	52	49	36	40	56	107	69	839
WSW	OSO	65	131	70	28	26	27	42	44	62	64	74	67	700
W	O	150	110	63	32	18	12	20	14	39	69	77	168	772
WNW	ONO	217	83	57	38	27	5	4	16	28	58	107	194	833
NW	NO	240	138	165	83	40	41	9	23	53	105	106	227	1228
NNW	NNO	174	150	158	180	102	51	25	32	49	183	121	181	1406

MEAN WIND ENERGY FROM ALL DIRECTIONS (MJ/m^2) — ENERGIE MOYENNE DU VENT POUR TOUTES LES DIRECTIONS

	JA	FE	MR	AL	MA	JN	JL	AU	SE	OC	NO	DE	AN
(MJ/m^2)	1572	1548	1735	1178	919	822	595	661	780	1253	1410	1815	14289

RECORDED WIND ENERGY (MJ/m^2) — ENERGIE ENREGISTREE DU VENT (MJ/m^2)

YEAR/ANNEE:	JA	FE	MR	AL	MA	JN	JL	AU	SE	OC	NO	DE	AN
1967	774	2925	2283	2708	636	1069	595	679	1239	1212	1526	1066	16710
1968	2184	1148	1481	665	1404	837	772	874	686	1288	2121	2556	16017
1969	2073	772	1509	1041	1587	950	488	562	764	1380	919	2142	14185
1970	1793	1586	1212	1596	664	769	532	610	787	971	828	2143	13491
1971	1636	1007	1247	776	638	923	433	637	842	1138	1840	1481	12597
1972	1619	1593	1317	1227	814	505	529	530	748	1430	1261	2272	13845
1973	1163	2089	1774	862	407	584	550	575	721	1601	984	1278	12588
1974	1461	2278	3062	762	789	1091	720	690	799	957	1079	1211	14898
1975	1108	536	1083	906	1116	655	673	642	619	1350	1954	2036	12679
1976	1912	1571	2384	1233	1137	833	660	812	599	1207	1593	1963	15905

MEAN OF RECORDED ENERGY (MJ/m^2) — MOYENNE DE L'ENERGIE ENREGISTREE

	JA	FE	MR	AL	MA	JN	JL	AU	SE	OC	NO	DE	AN
(MJ/m^2)	1572	1548	1735	1178	919	822	595	661	780	1253	1410	1815	14289

STANDARD DEVIATION OF RECORDED ENERGY (MJ/m^2) — ECART TYPE DE L'ENERGIE ENREGISTREE

	JA	FE	MR	AL	MA	JN	JL	AU	SE	OC	NO	DE	AN
(MJ/m^2)	451	731	642	606	378	197	108	109	178	201	463	513	1528

BATTLE HARBOUR LOR, NFLD/TN

WIND SUMMARY
ANALYSIS PERIOD: 1967 JA to/a 1976 DE :PERIODE D'ANALYSE
SUMMAIRE DU VENT

LATITUDE: 52°15'N
LONGITUDE: 55°36'W/O
ELEVATION: 9 m

HOURLY MEAN WIND POWER (W/m²) — MOYENNE HORAIRE DE LA PUISSANCE DU VENT (W/m²)

HOUR/HEURE:	JA	FE	MR	AL	MA	JN	JL	AU	SE	QC	NO	DE	AN
0	541	603	616	425	307	259	166	207	249	414	512	685	423
1	556	665	615	433	302	246	154	192	235	409	510	673	400
2	562	684	624	447	298	238	151	183	232	418	527	678	432
3	519	652	628	447	291	237	149	179	232	424	550	679	408
4	520	668	615	441	290	235	150	179	236	413	558	679	406
5	584	721	622	454	296	238	150	181	250	404	555	670	432
6	617	706	639	471	304	248	153	188	266	413	540	648	427
7	635	660	668	488	324	265	160	202	285	447	533	645	435
8	659	651	688	503	342	285	175	218	300	485	546	656	465
9	667	686	665	489	351	306	203	235	306	499	560	655	464
10	657	711	656	461	363	325	237	252	318	519	558	658	473
11	639	702	675	447	371	350	270	269	336	550	552	673	486
12	624	705	669	448	374	381	300	292	347	552	555	688	491
13	598	725	667	461	378	407	329	316	358	538	558	684	501
14	581	737	698	467	387	426	345	332	367	544	552	664	505
15	593	725	718	459	400	438	332	333	369	550	534	659	513
16	601	684	708	450	405	428	303	325	361	535	523	678	496
17	607	647	692	445	392	396	280	311	342	498	542	715	487
18	626	616	674	449	369	369	263	293	323	457	563	723	479
19	633	580	664	457	351	356	246	277	318	434	559	701	458
20	576	554	637	455	348	331	229	263	316	438	554	695	459
21	495	524	575	445	347	295	210	246	308	444	556	688	418
22	482	507	552	435	331	277	195	230	297	430	541	681	411
23	519	539	586	427	315	270	184	220	276	419	520	691	408
MONTHLY MEAN WIND POWER (W/m²) — MOYENNE MENSUELLE DE LA PUISSANCE DU VENT	587	652	648	454	343	317	222	247	301	468	544	678	453

WEIBULL DISTRIBUTION PARAMETERS — PARAMETRE DE WEIBULL

C: SCALE FACTOR (km/h) — C: FACTEUR D'ECHELLE (km/h)
K: SHAPE FACTOR (dimensionless) — K: FACTEUR DE FORME (sans dimension)

	JA	FE	MR	AL	MA	JN	JL	AU	SE	QC	NO	DE	AN
C:	33.1	33.9	34.6	28.5	25.5	25.4	21.7	23.0	25.3	29.9	32.6	36.3	29.5
K:	2.07	1.78	1.88	1.73	1.76	1.75	1.86	1.87	1.94	1.95	2.20	2.07	1.74

The MAXIMUM OBSERVED WIND SPEED in the analysis period was 129 km/h. It was observed 4 times.
La VITESSE MAXIMUM DU VENT OBSERVEE pendant la periode d'analyse etait 129 km/h. Elle a etait observee 4 fois.

BATTLE HARBOUR LOR, NFLD/TN

WIND SUMMARY
ANALYSIS PERIOD: 1967 JA to/a 1976 DE :PERIODE D'ANALYSE
SUMMAIRE DU VENT

LATITUDE: 52°15'N
LONGITUDE: 55°36'W/O
ELEVATION: 9 m

WIND ENERGY PROFILE
%t: FRACTION OF TIME WHEN WIND SPEEDS ARE GREATER THAN v (%)
pe: TOTAL ENERGY IN WINDS HAVING A SPEED GREATER THAN v (MJ/m²)
%e: FRACTION OF MONTHLY TOTAL WIND ENERGY REPRESENTED BY pe (%)

PROFIL DE L'ENERGIE DU VENT
%t: FRACTION DU TEMPS DURANT LAQUELLE LA VITESSE DU VENT EST SUPERIEURE A v (%)
pe: ENERGIE TOTALE DES VENTS AYANT UNE VITESSE SUPERIEURE A v (MJ/m²)
%e: FRACTION DE L'ENERGIE MENSUELLE TOTALE DU VENT DENOTEE PAR pe (%)

v: (km/h)		JA	FE	MR	AL	MA	JN	JL	AU	SE	OC	NO	DE	AN
5	%t	98.2	97.2	97.5	95.0	93.8	93.9	92.2	92.6	94.3	96.2	98.2	98.4	95.6
	pe	1572.4	1547.7	1735.0	1177.6	919.1	821.5	595.2	661.1	780.3	1253.3	1410.4	1814.9	14288.6
	%e	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
10	%t	92.5	91.8	92.8	86.4	82.9	83.7	79.1	82.5	86.9	89.9	93.5	94.9	88.1
	pe	1570.9	1546.5	1733.9	1175.6	916.5	819.1	592.2	658.7	778.5	1251.7	1409.3	1814.0	14267.0
	%e	99.9	99.9	99.9	99.8	99.7	99.7	99.5	99.6	99.8	99.9	99.9	100.0	99.8
15	%t	85.6	85.0	85.8	76.4	72.4	72.2	66.8	71.6	76.3	81.4	86.0	89.2	79.1
	pe	1565.2	1541.5	1728.2	1168.0	908.4	810.8	582.9	650.7	770.7	1245.1	1403.5	1809.4	14184.3
	%e	99.5	99.6	99.6	99.2	98.6	98.7	97.9	98.4	98.8	99.3	99.5	99.7	99.3
20	%t	70.2	70.0	71.3	60.6	56.6	54.9	50.3	54.6	58.4	66.6	72.3	77.9	63.6
	pe	1532.5	1512.7	1697.9	1136.7	877.0	777.5	551.0	617.8	737.2	1215.4	1376.1	1785.5	13817.2
	%e	97.5	97.7	97.9	96.5	95.4	94.6	92.6	93.4	94.5	97.0	97.6	98.4	96.7
25	%t	55.9	54.9	58.3	47.2	43.8	40.2	36.5	39.6	42.6	53.0	57.8	64.9	49.6
	pe	1464.9	1446.9	1637.8	1077.8	818.5	713.9	490.2	551.5	668.5	1153.5	1311.0	1723.6	13058.2
	%e	93.2	93.5	94.4	91.5	89.0	86.9	82.3	83.4	85.7	92.0	93.0	95.0	91.4
30	%t	39.1	38.7	41.4	32.8	29.4	25.9	21.8	23.6	26.6	37.9	39.9	48.1	33.8
	pe	1326.5	1325.3	1502.0	967.0	705.6	606.3	377.3	430.2	549.1	1034.1	1172.7	1584.0	11579.9
	%e	84.4	85.6	86.6	82.1	76.8	73.8	63.4	65.1	70.4	82.5	83.1	87.3	81.0
35	%t	23.2	21.8	24.4	17.6	13.9	12.6	7.9	8.7	12.6	20.9	23.4	28.3	17.9
	pe	1114.3	1121.8	1274.7	773.7	506.3	443.5	205.0	246.2	381.6	817.1	968.0	1319.8	9172.0
	%e	70.9	72.5	73.5	65.7	55.1	54.0	34.4	37.2	48.9	65.2	68.6	72.7	64.2
40	%t	15.2	14.1	15.0	11.0	7.0	6.4	2.4	3.4	5.8	11.6	14.6	17.5	10.3
	pe	931.6	958.6	1068.2	634.7	357.7	316.0	90.6	134.3	239.8	614.1	779.0	1077.2	7201.9
	%e	59.2	61.9	61.6	53.9	38.9	38.5	15.2	20.3	30.7	49.0	55.2	59.4	50.4
45	%t	11.8	11.0	11.1	8.3	4.8	4.4	1.2	2.1	3.5	9.2	11.7	14.3	7.8
	pe	824.2	868.3	946.7	552.8	291.4	257.5	55.8	86.0	172.0	538.2	691.0	975.8	6269.8
	%e	52.4	56.1	54.6	46.9	31.7	31.3	9.4	14.5	22.0	42.9	49.0	53.8	43.9
50	%t	7.4	6.6	7.1	4.8	2.4	2.2	0.5	0.8	1.5	4.6	6.5	8.0	4.4
	pe	640.2	703.6	784.4	415.2	195.2	174.0	28.6	45.4	94.8	355.3	491.1	717.0	4644.9
	%e	40.7	45.5	45.2	35.3	21.2	21.2	4.8	6.9	12.1	28.3	34.8	39.5	32.5

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BATTLE HARBOUR LOR, NFLD/TN

WIND SUMMARY / SUMMAIRE DU VENT

ANALYSIS PERIOD: 1967 JA to/a 1976 DE :PERIODE D'ANALYSE

LATITUDE: 52°15'N
LONGITUDE: 55°36'W/O
ELEVATION: 9 m

WIND ENERGY PROFILE
%t: FRACTION OF TIME WHEN WIND SPEEDS ARE GREATER THAN v (%)
pe: TOTAL ENERGY IN WINDS HAVING A SPEED GREATER THAN v (MJ/m²)
%e: FRACTION OF MONTHLY TOTAL WIND ENERGY REPRESENTED BY pe (%)

PROFIL DE L'ENERGIE DU VENT
%t: FRACTION DU TEMPS DURANT LAQUELLE LA VITESSE DU VENT EST SUPERIEURE A v (%)
pe: ENERGIE TOTALE DES VENTS AYANT UNE VITESSE SUPERIEURE A v (MJ/m²)
%e: FRACTION DE L'ENERGIE MENSUELLE TOTALE DU VENT DENOTEE PAR pe (%)

		JA	FE	MR	AL	MA	JN	JL	AU	SE	OC	NO	DE	AN
55	%t	5.9	5.9	6.0	3.4	1.7	1.6	0.3	0.4	1.0	3.6	5.2	6.8	3.5
	pe	560.3	669.8	721.1	343.5	159.3	140.8	16.6	26.1	69.7	306.0	425.8	656.2	4085.2
	%e	35.6	43.3	41.6	29.2	17.3	17.1	2.8	3.9	8.9	24.4	30.2	36.2	28.7
60	%t	3.1	3.5	3.4	2.0	0.9	0.7	0.0	0.1	0.2	1.5	2.5	3.5	1.8
	pe	365.7	519.2	547.0	248.0	105.9	86.5	2.3	6.0	22.9	167.0	255.9	432.5	2758.9
	%e	23.3	33.5	31.5	21.1	11.5	10.5	0.4	0.9	2.9	13.3	18.1	23.8	19.3
65	%t	1.2	1.9	1.9	0.9	0.3	0.3		0.0	0.1	0.4	0.7	1.4	0.8
	pe	193.6	377.1	410.5	149.3	51.3	46.5		1.4	10.0	69.9	93.2	236.8	1639.7
	%e	12.3	24.4	23.7	12.7	5.6	5.7		0.2	1.3	5.6	6.6	13.0	11.5
70	%t	1.0	1.8	1.8	0.7	0.3	0.2			0.1	0.4	0.5	1.2	0.7
	pe	174.8	367.4	397.6	130.3	48.1	41.8			10.0	60.6	74.7	213.1	1518.5
	%e	11.1	23.7	22.9	11.1	5.2	5.1			1.3	4.8	5.3	11.7	10.6
75	%t	0.4	1.0	1.0	0.4	0.1	0.1			0.0	0.1	0.1	0.5	0.3
	pe	93.2	259.3	286.9	90.9	14.8	23.7			4.6	28.8	21.3	122.7	946.3
	%e	5.9	16.8	16.5	7.7	1.6	2.9			0.6	2.3	1.5	6.8	6.6
80	%t	0.1	0.5	0.6	0.2	0.0	0.0				0.0	0.0	0.2	0.1
	pe	33.6	171.1	199.5	60.2	0.0	11.4				9.1	0.0	57.5	542.4
	%e	2.1	11.1	11.5	5.1	0.0	1.4				0.7	0.0	3.2	3.8
85	%t	0.1	0.4	0.5	0.2								0.1	0.1
	pe	33.6	165.3	193.5	48.7								51.5	513.1
	%e	2.1	10.7	11.1	4.1								2.8	3.6
90	%t	0.0	0.3	0.4	0.1								0.1	0.1
	pe	13.2	144.2	151.4	28.8								38.2	385.8
	%e	0.8	9.3	8.7	2.4								2.1	2.7
95	%t		0.3	0.3	0.1								0.1	0.1
	pe		140.2	143.4	24.8								26.5	358.4
	%e		9.1	8.3	2.1								1.5	2.5
100	%t		0.2	0.2	0.0									0.0
	pe		99.4	88.0	16.0									230.7
	%e		6.4	5.1	1.4									1.6

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BATTLE HARBOUR LDR, NFLD/TN

WIND SUMMARY — SUMMAIRE DU VENT

ANALYSIS PERIOD: 1967 JA to/a 1976 DE :PERIODE D'ANALYSE

LATITUDE: 52°15'N
LONGITUDE: 55°36'W/O
ELEVATION: 9 m

WIND ENERGY PROFILE	%t: FRACTION OF TIME WHEN WIND SPEEDS ARE GREATER THAN v	(%)
	pe: TOTAL ENERGY IN WINDS HAVING A SPEED GREATER THAN v	(MJ/m^2)
	%e: FRACTION OF MONTHLY TOTAL WIND ENERGY REPRESENTED BY pe	(%)
PROFIL DE L'ENERGIE DU VENT	%t: FRACTION DU TEMPS DURANT LAQUELLE LA VITESSE DU VENT EST SUPERIEURE A v	(%)
	pe: ENERGIE TOTALE DES VENTS AYANT UNE VITESSE SUPERIEURE A v	(MJ/m^2)
	%e: FRACTION DE L'ENERGIE MENSUELLE TOTALE DU VENT DENOTEE PAR pe	(%)

		JA	FE	MR	AL	MA	JN	JL	AU	SE	OC	NO	DE	AN
105	%t		0.2	0.1										0.0
	pe		93.9	44.4										148.7
	%e		6.1	2.6										1.0
110	%t		0.2	0.1										0.0
	pe		93.9	44.4										148.7
	%e		6.1	2.6										1.0
115	%t		0.0	0.0										0.0
	pe		31.0	17.3										58.8
	%e		2.0	1.0										0.4
TOTAL WIND ENERGY (MJ/m^2) — ENERGIE TOTALE DU VENT		1572	1548	1735	1178	919	822	595	661	780	1253	1410	1815	14289

BATTLE HARBOUR LOR, NFLD/TN
WIND SUMMARY / SUMMAIRE DU VENT
ANALYSIS PERIOD: 1967 JA to/a 1976 DE :PERIODE D'ANALYSE

LATITUDE: 52°15'N
LONGITUDE: 55°36'W/O
ELEVATION: 9 m

DURATION AND FREQUENCY OF PERIODS OF WIND SPEED ≤ 15 km/h
x: DURATION OF PERIOD (hours)
n: NUMBER OF PERIODS THAT LASTED x HOURS OR MORE
f: NUMBER OF PERIODS THAT LASTED x HOURS

DUREE ET FREQUENCE DES PERIODES AVEC UN VENT ≤ 15 km/h
x: DUREE DES PERIODES (heures)
n: NOMBRE DE PERIODES DE x HEURES OU PLUS
f: NOMBRE DE PERIODES DE x HEURES

x	n	f	x	n	f	x	n	f	x	n	f	x	n	f
1	5414	2288	9	474	99	16	117	23	23	28	4	31	10	1
2	3126	940	10	375	70	17	94	24	24	24	4	32	9	2
3	2186	568	11	305	53	18	70	9	25	20	2	33	7	1
4	1618	431	12	252	45	19	61	14	26	18	3	37	6	1
5	1187	260	13	207	38	20	47	11	27	15	3	39	5	3
6	927	184	14	169	30	21	36	3	28	12	1	40	2	1
7	743	145	15	139	22	22	33	5	30	11	1	42	1	1
8	598	124												

The wind speed was ≤ 15 km/h, for an average of 541 periods per year, or 1838 hours per year.

La vitesse du vent etait ≤ 15 km/h, pour une moyenne annuelle de 541 periodes, ou 1838 heures.

TOTAL DURATION OF PERIODS ≤ 15 km/h (% of time) / DUREE TOTALE DES PERIODES ≤ 15 km/h (% du temps)

JA	FE	MR	AL	MA	JN	JL	AU	SE	OC	ND	DE	AN
14	14	14	23	27	27	33	28	23	18	14	10	20

BATTLE HARBOUR LOR, NFLD/TN

WIND SUMMARY
SUMMAIRE DU VENT
ANALYSIS PERIOD: 1967 JA to/a 1976 DE :PERIODE D'ANALYSE

LATITUDE: 52°15'N
LONGITUDE: 55°36'W/O
ELEVATION: 9 m

DURATION AND FREQUENCY OF PERIODS OF WIND SPEED > 35 km/h
x: DURATION OF PERIOD (hours)
n: NUMBER OF PERIODS THAT LASTED x HOURS OR MORE
f: NUMBER OF PERIODS THAT LASTED x HOURS

DUREE ET FREQUENCE DES PERIODES AVEC UN VENT > 35 km/h
x: DUREE DES PERIODES (heures)
n: NOMBRE DE PERIODES DE x HEURES OU PLUS
f: NOMBRE DE PERIODES DE x HEURES

x	n	f	x	n	f	x	n	f	x	n	f	x	n	f
1	3716	1776	12	325	35	23	113	7	34	43	8	50	14	1
2	1940	578	13	290	25	24	106	10	35	35	1	53	13	3
3	1362	317	14	265	25	25	96	11	36	34	4	54	10	1
4	1045	198	15	240	24	26	85	6	37	30	2	57	9	1
5	847	143	16	216	28	27	79	4	39	28	2	58	8	1
6	704	110	17	188	12	28	75	5	40	26	3	67	7	1
7	594	77	18	176	15	29	70	6	41	23	2	72	6	1
8	517	63	19	161	14	30	64	9	43	21	2	74	5	2
9	454	49	20	147	15	31	55	4	44	19	2	85	3	1
10	405	43	21	132	9	32	51	6	45	17	1	94	2	1
11	362	37	22	123	10	33	45	2	48	16	2	119	1	1

The wind speed was > 35 km/h, for an average of 372 periods per year, or 1571 hours per year.

La vitesse du vent etait > 35 km/h, pour une moyenne annuelle de 372 periodes, ou 1571 heures.

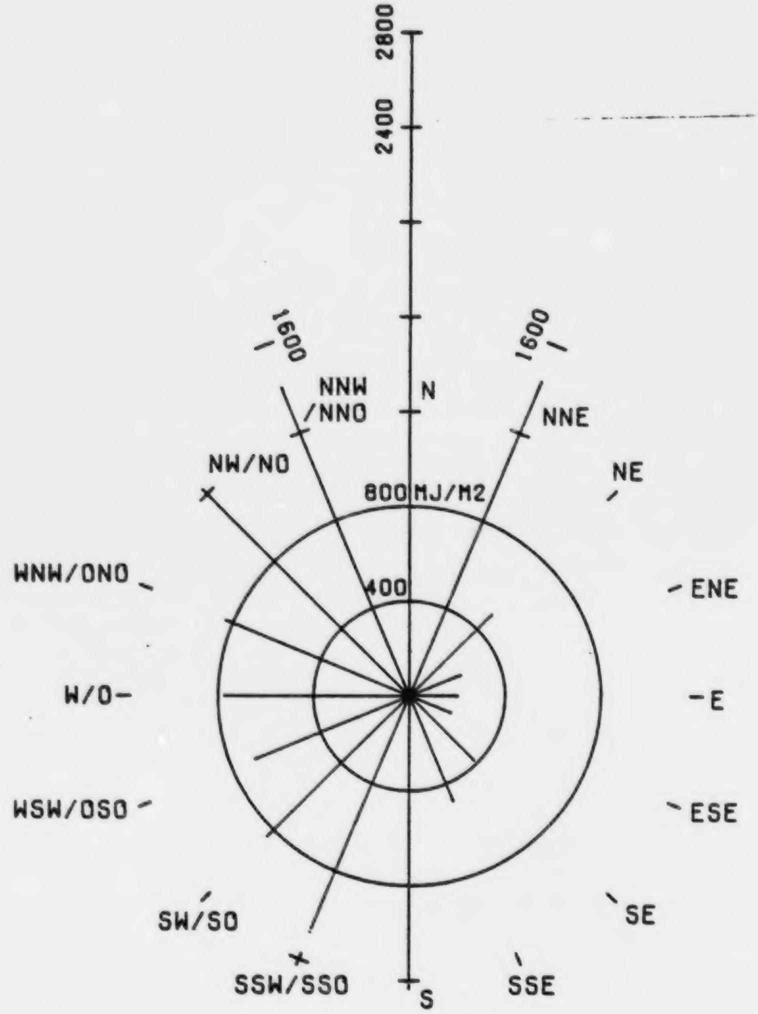
DURATION AND FREQUENCY OF PERIODS OF WIND SPEED >100 km/h
x: DURATION OF PERIOD (hours)
n: NUMBER OF PERIODS THAT LASTED x HOURS OR MORE
f: NUMBER OF PERIODS THAT LASTED x HOURS

DUREE ET FREQUENCE DES PERIODES AVEC UN VENT >100 km/h
x: DUREE DES PERIODES (heures)
n: NOMBRE DE PERIODES DE x HEURES OU PLUS
f: NOMBRE DE PERIODES DE x HEURES

x	n	f	x	n	f	x	n	f	x	n	f	x	n	f
1	16	9	2	7	2	3	5	2	4	3	2	7	1	1

The wind speed was >100 km/h, for an average of 2 periods per year, or 3 hours per year.

La vitesse du vent etait >100 km/h, pour une moyenne annuelle de 2 periodes, ou 3 heures.

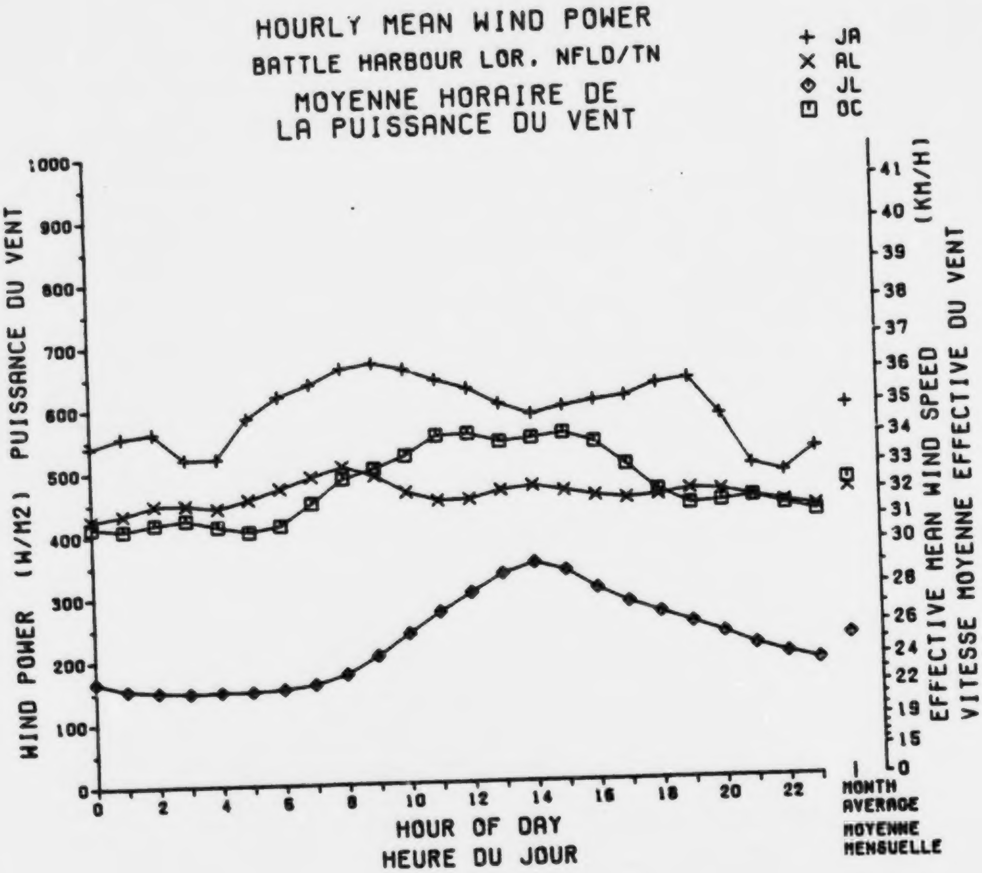


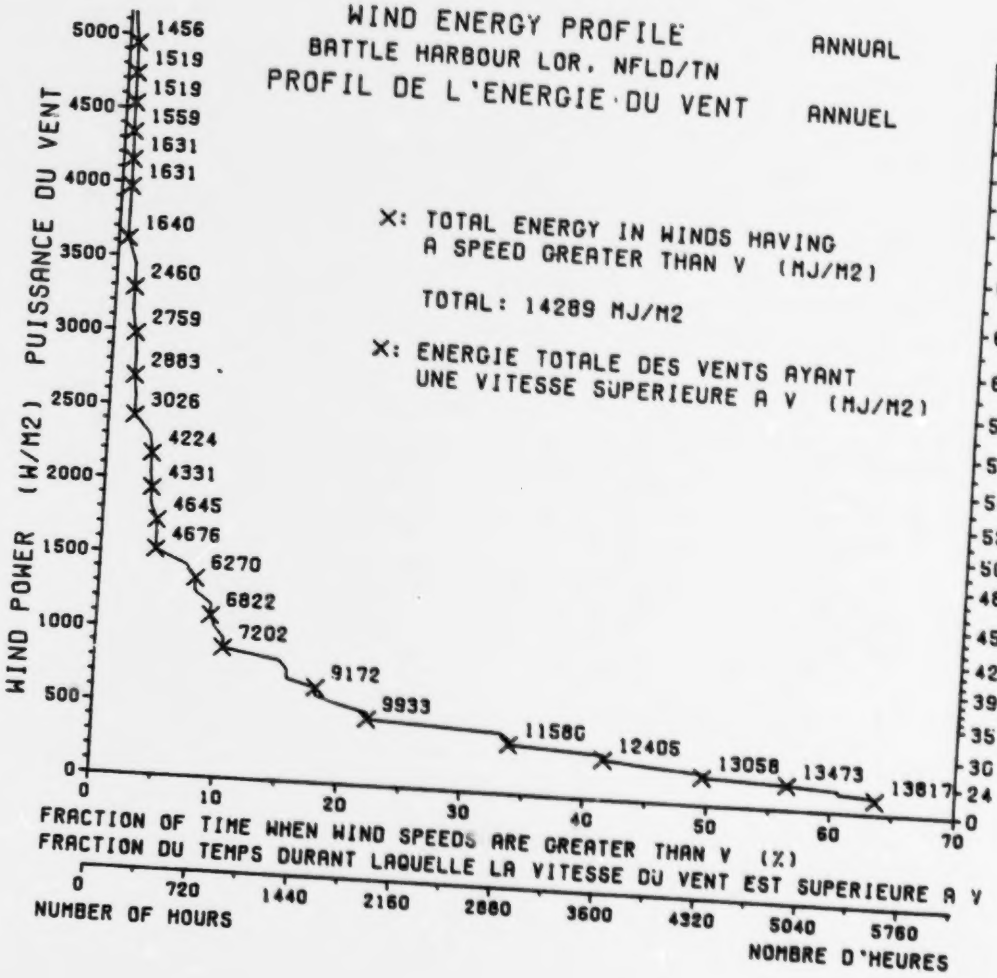
ANNUAL DIRECTED WIND ENERGY

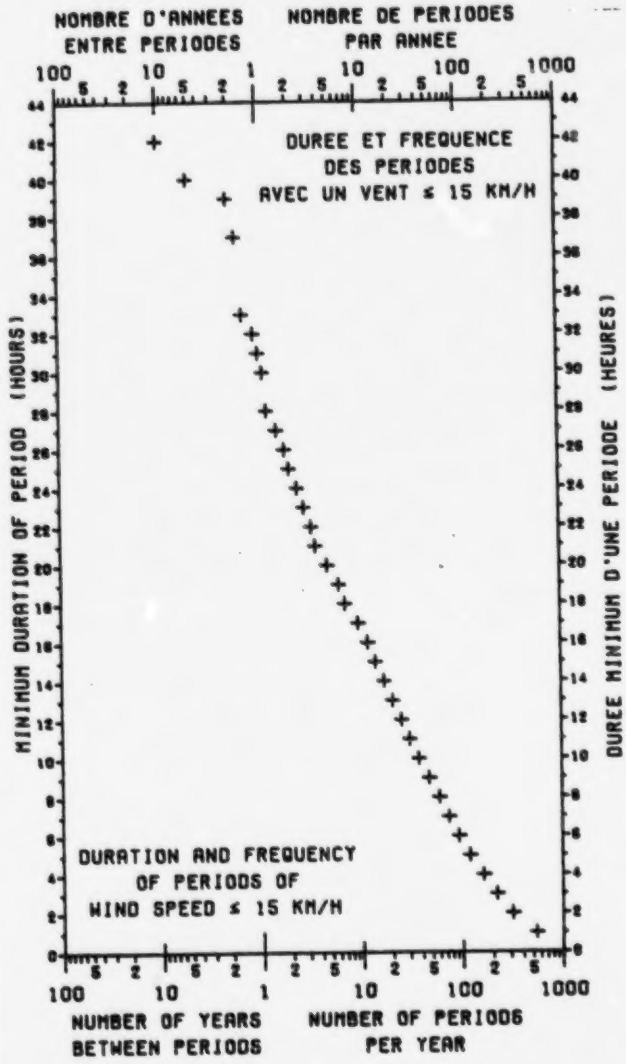
TOTAL: 14289 MJ/M2

BATTLE HARBOUR LOR, NFLD/TN

ENERGIE ANNUELLE DU VENT
SELON LA DIRECTION


HOURLY MEAN WIND POWER
BATTLE HARBOUR LOR. NFLD/TN
MOYENNE HORAIRE DE
LA PUISSANCE DU VENT


WIND ENERGY PROFILE
BATTLE HARBOUR LDR, NFLD/TN
ANNUAL
PROFIL DE L'ENERGIE DU VENT
ANNUEL
X: TOTAL ENERGY IN WINDS HAVING A SPEED GREATER THAN V (MJ/M2)
TOTAL: 14289 MJ/M2
X: ENERGIE TOTALE DES VENTS AYANT UNE VITESSE SUPERIEURE A V (MJ/M2)
WIND POWER (W/M2) PUISSANCE DU VENT
5000
4500
4000
3500
3000
2500
2000
1500
1000
500
0
1456
1519
1519
1559
1631
1631
1640
2460
2759
2883
3026
4224
4331
4645
4676
6270
6822
7202
9172
9933
11580
12405
13058
13473
13817
V: WIND SPEED (KM/H) VITESSE DU VENT
71
70
69
68
67
66
64
62
60
58
56
54
52
50
48
45
42
39
35
30
24
0
0
10
20
30
40
50
60
70
FRACTION OF TIME WHEN WIND SPEEDS ARE GREATER THAN V (%)
FRACTION DU TEMPS DURANT LAQUELLE LA VITESSE DU VENT EST SUPERIEURE A V
0
720
1440
2160
2880
3600
4320
5040
5760
NUMBER OF HOURS
NOMBRE D'HEURES



BATTLE HARBOUR LDR. NFLD/TN

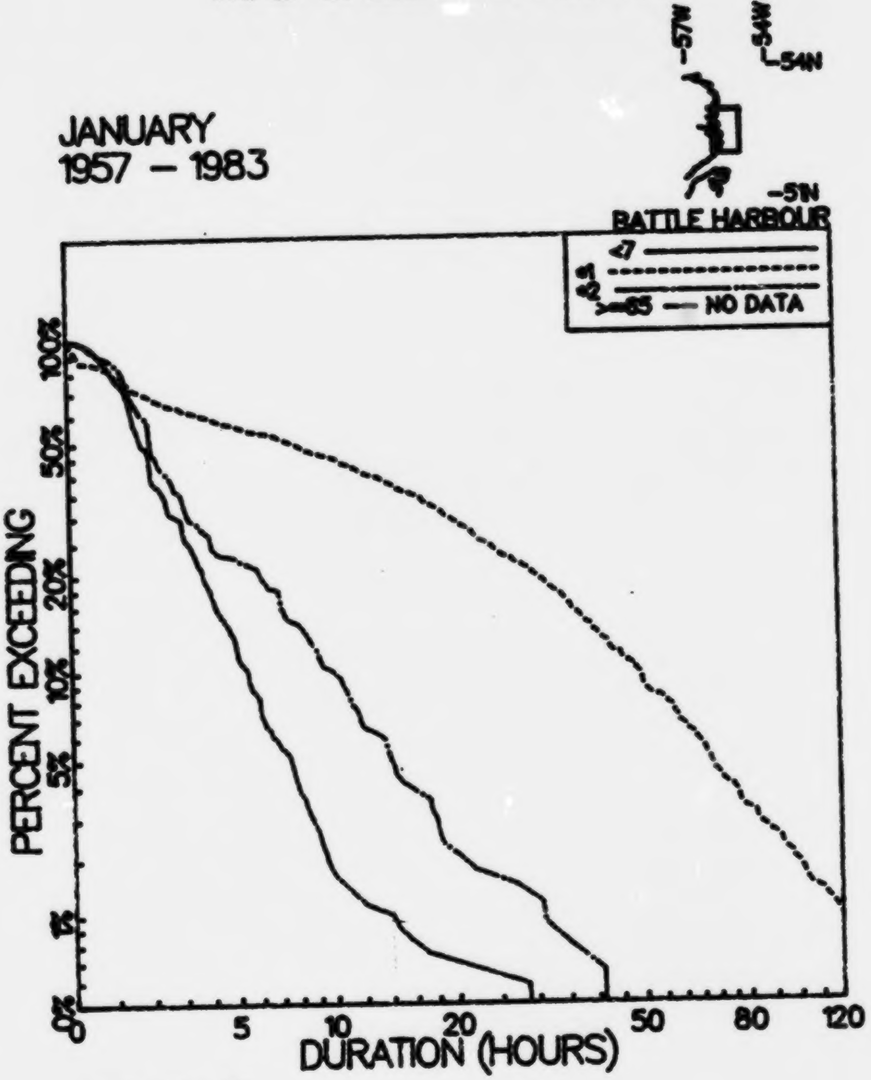
DUST Statistical Interpretation

The duration statistics for Battle Harbour are presented in graphical form for all twelve months and for a range of wind speed ranges. The different wind speed ranges are required as typical of cut-in and cut-out speeds of several wind machines. the durations are interpreted as follows: The duration in hours is given on the horizontal axis. The corresponding vertical axis is a measure of the percent of durations that exceed that duration length.

For example, for January the speed range of less than seven (7) knots/hr. for the duration of fourteen hours is exceedingly only one percent of all durations which are less than seven knots/hr. or 99% of the time the wind speed less than 7 knots will be less than 14 hours in duration.

ENVIRONMENT CANADA
ATMOSPHERIC ENVIRONMENT CANADIAN CLIMATE CENTRE

WIND SPEED DURATIONS

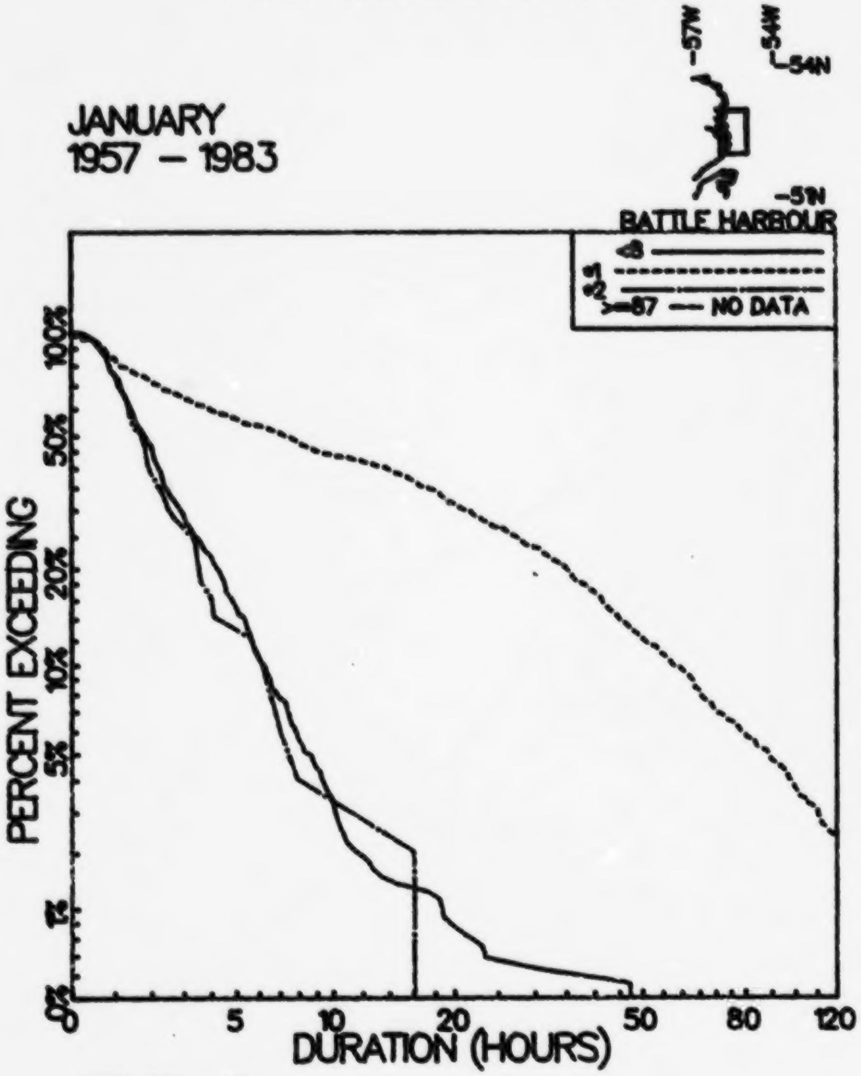


*1>=7 AND <=30
*2BEGIN: > 30 AND < 65 END: <=30 OR >=65

2

WIND SPEED DURATIONS

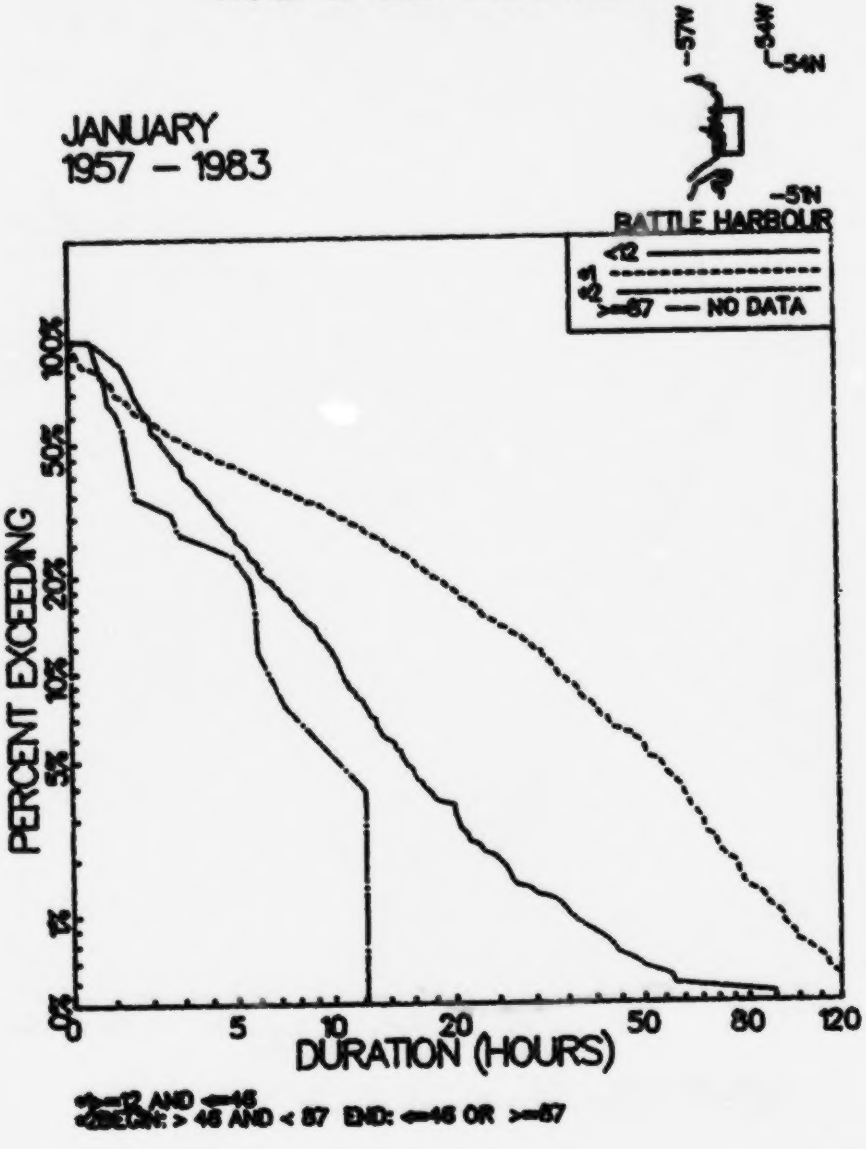
JANUARY
1957 – 1983



<1>=8 AND <=43
<2BEGIN: > 43 AND < 87 END: <=43 OR >=87

WIND SPEED DURATIONS

JANUARY
1957 – 1983

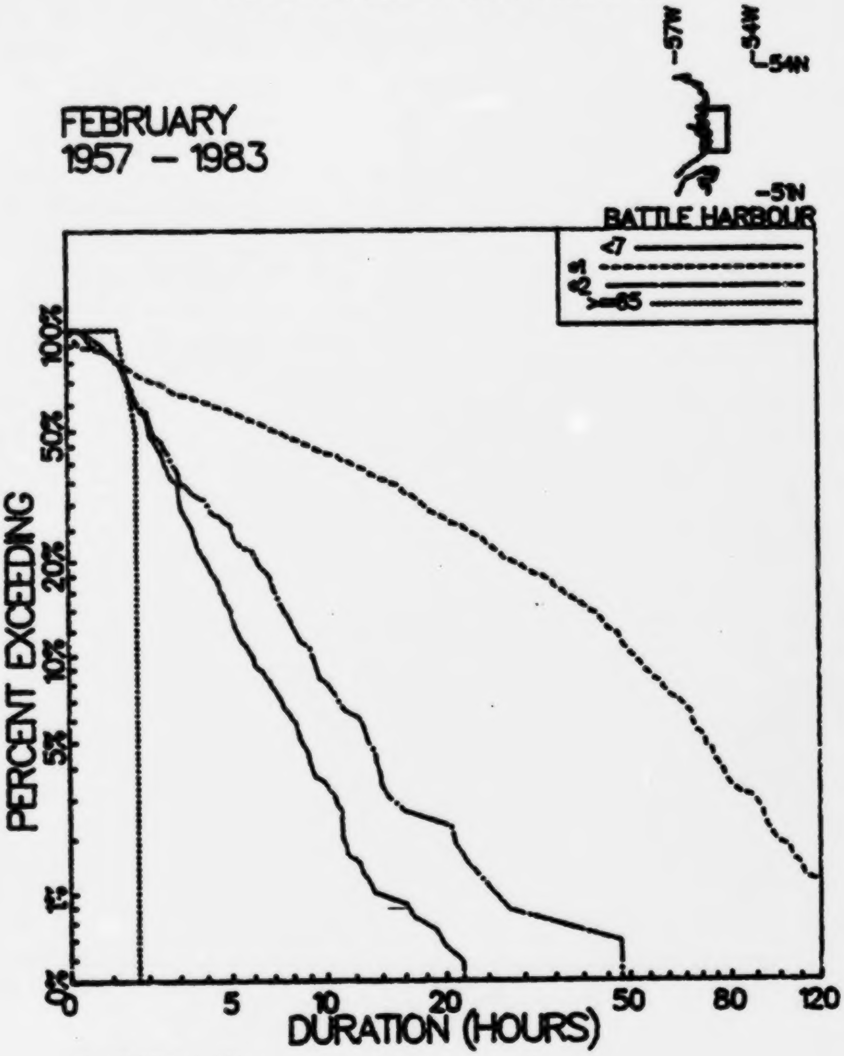


*1>=12 AND <=46
*2BEGIN: > 46 AND < 87 END: <=46 OR >=87

4

ENVIRONMENT CANADA
ATMOSPHERIC ENVIRONMENT CANADIAN CLIMATE CENTRE

WIND SPEED DURATIONS



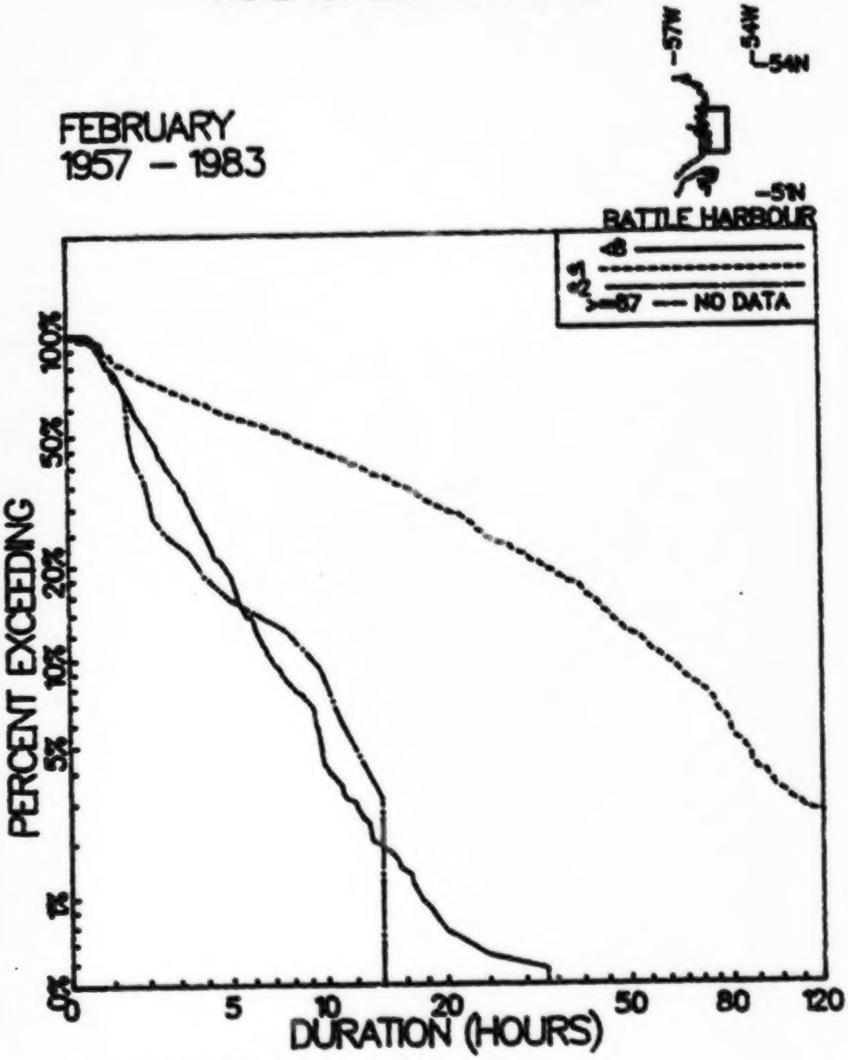
<1>=7 AND <=30
<2>BEGIN: > 30 AND < 65 END: <=30 OR >=65

5.

ENVIRONMENT CANADA
ATMOSPHERIC ENVIRONMENT CANADIAN CLIMATE CENTRE

WIND SPEED DURATIONS

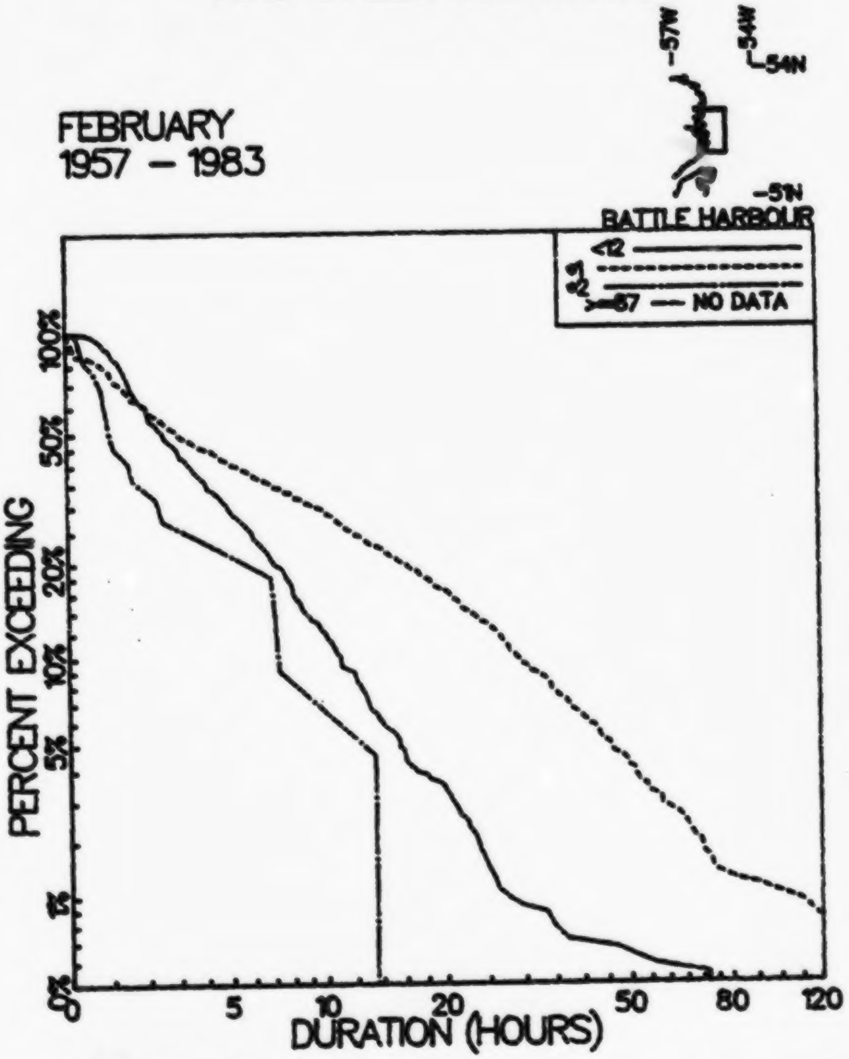
FEBRUARY
1957 – 1983



*1>=8 AND <=43
*2BEGIN: > 43 AND < 87 END: <=43 OR >=87

6

WIND SPEED DURATIONS



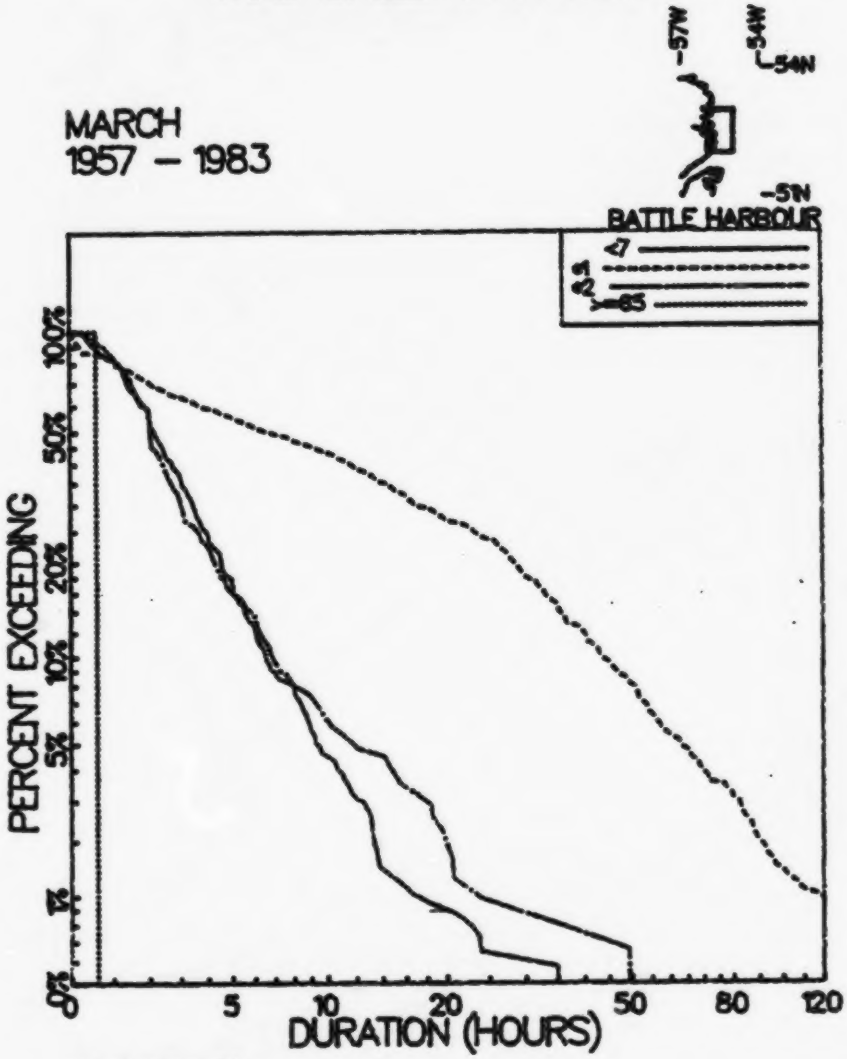
<1>=12 AND <=46
<2BEGIN: > 46 AND < 87 END: <=46 OR >=87

1

ENVIRONMENT CANADA
ATMOSPHERIC ENVIRONMENT CANADIAN CLIMATE CENTRE

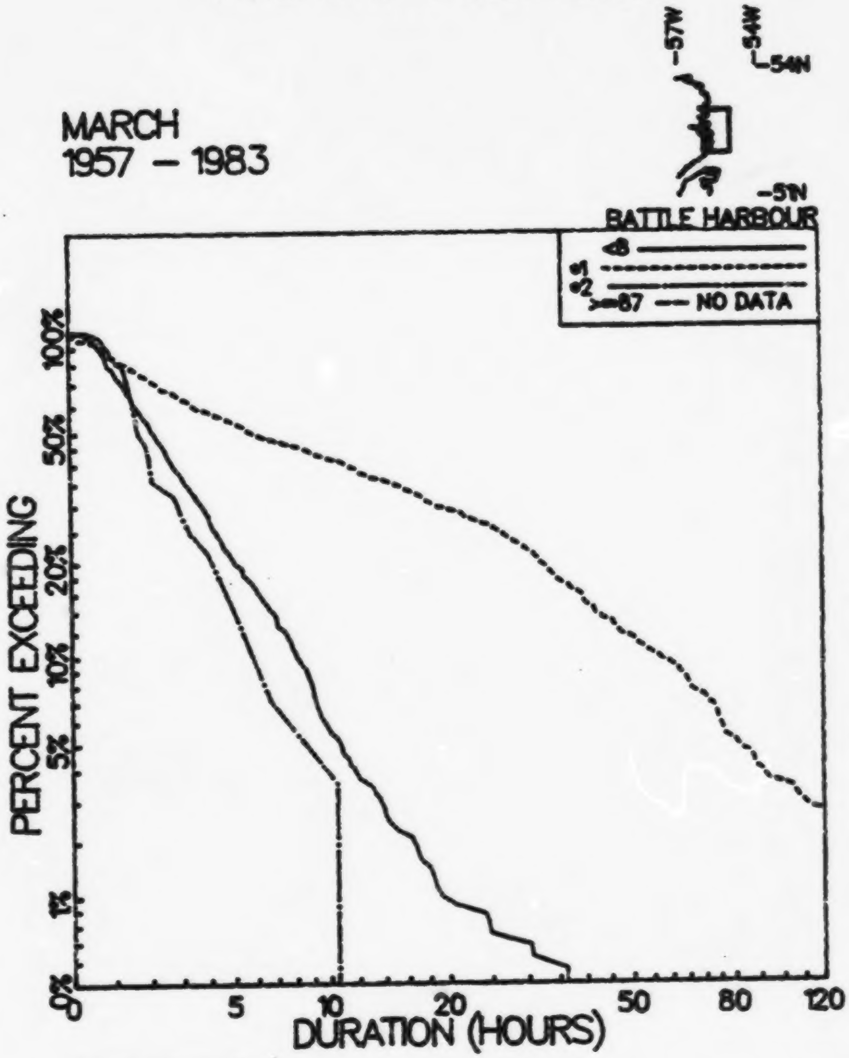
WIND SPEED DURATIONS

MARCH
1957 – 1983



<1>=7 AND <=30
<2BEGIN: > 30 AND < 65 END: <=30 OR >=65

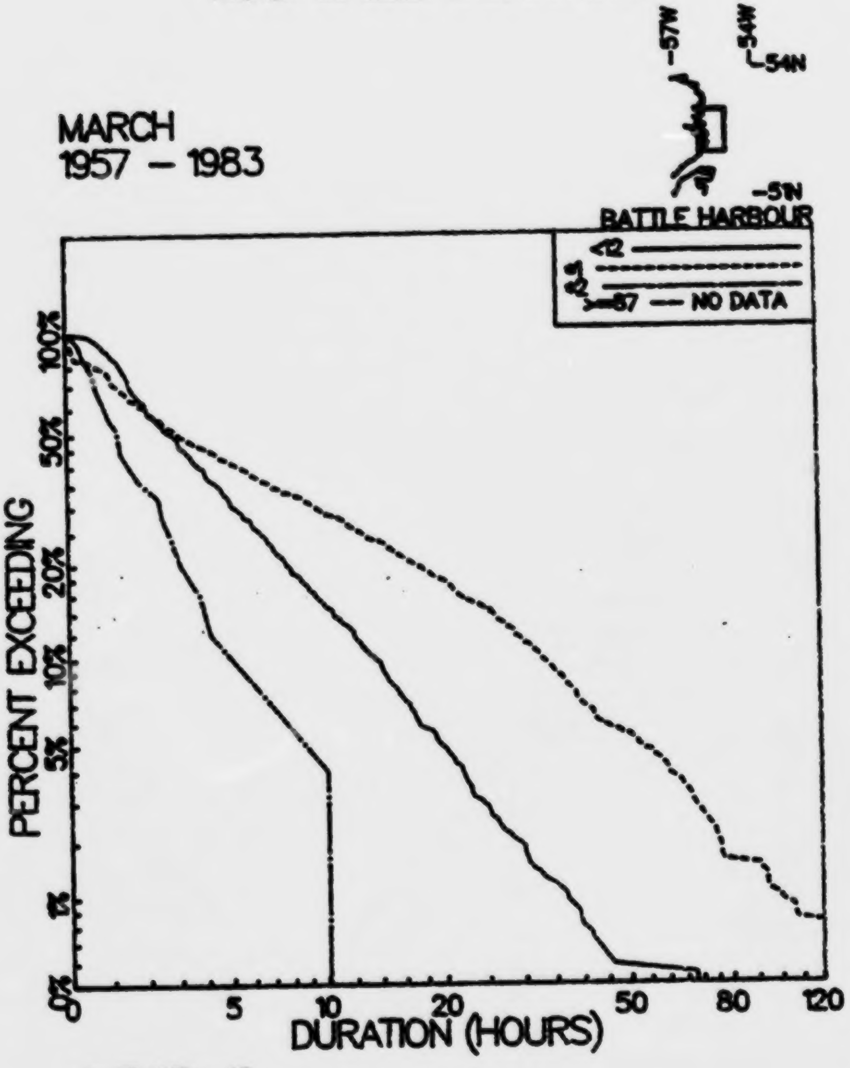
WIND SPEED DURATIONS



<1>=8 AND <=43
<2BEGIN: > 43 AND < 87 END: <=43 OR >=87

9

WIND SPEED DURATIONS



*1>=12 AND <=46
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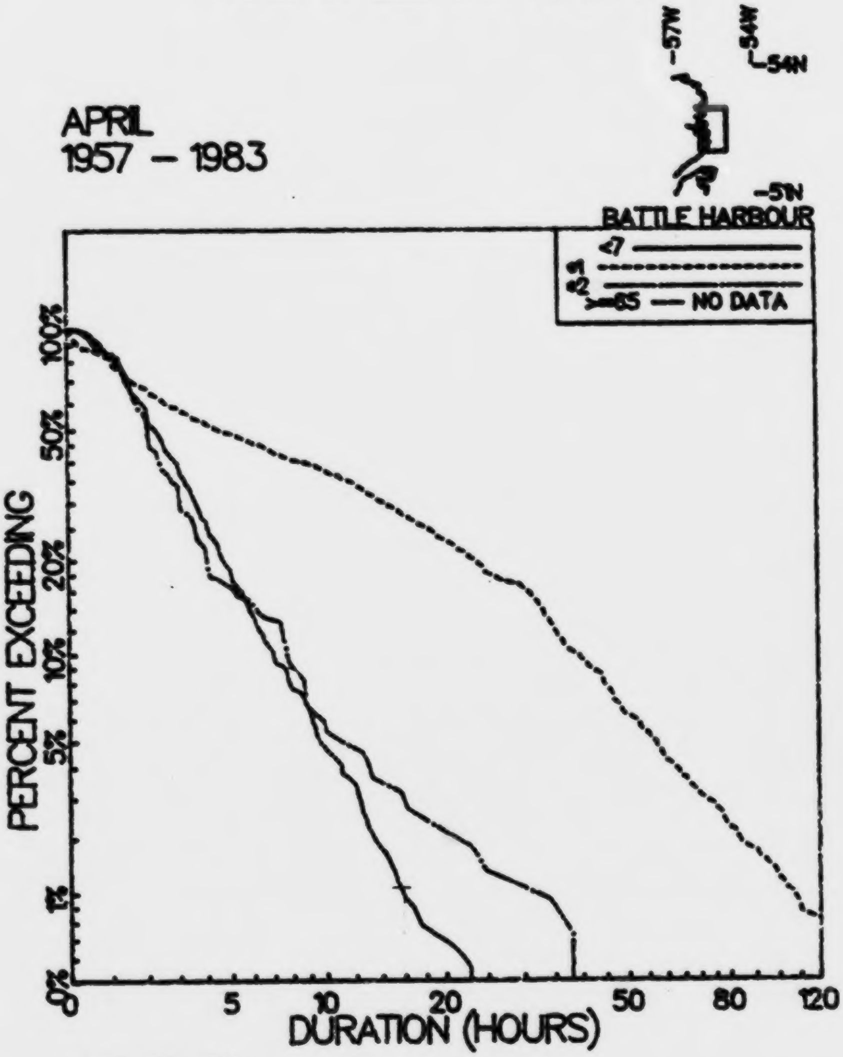
10

WIND SPEED DURATIONS



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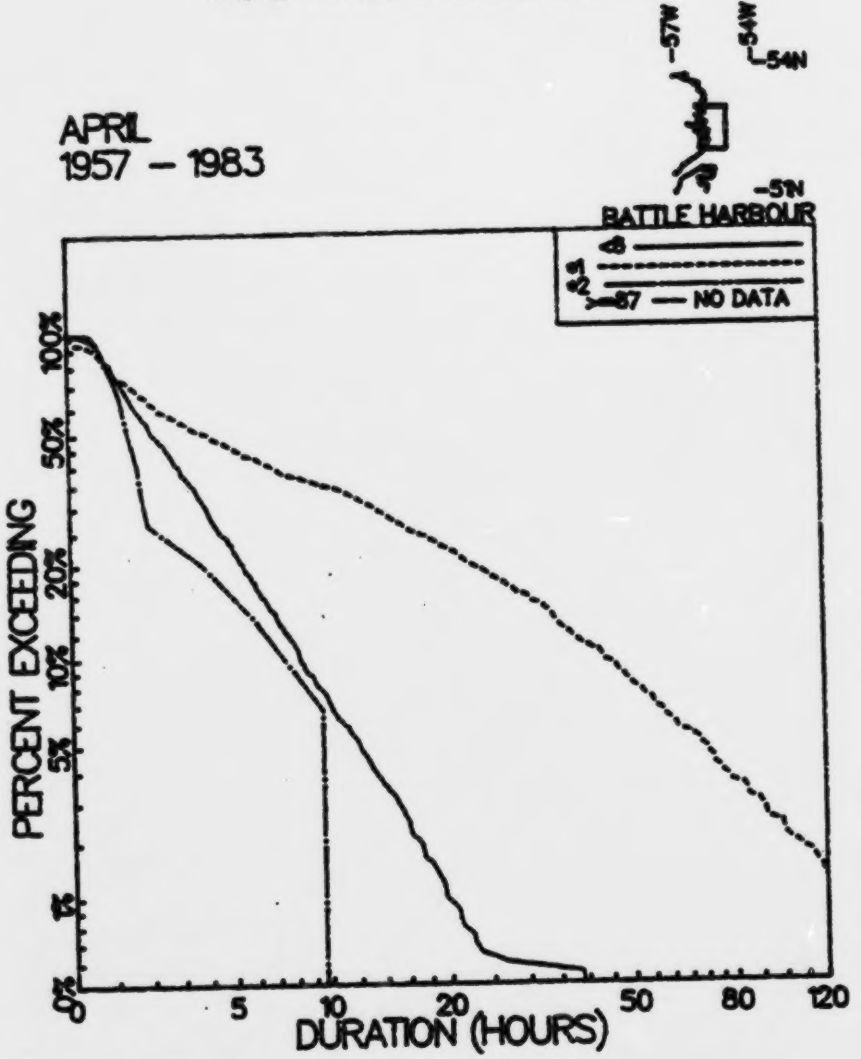
WIND SPEED DURATIONS



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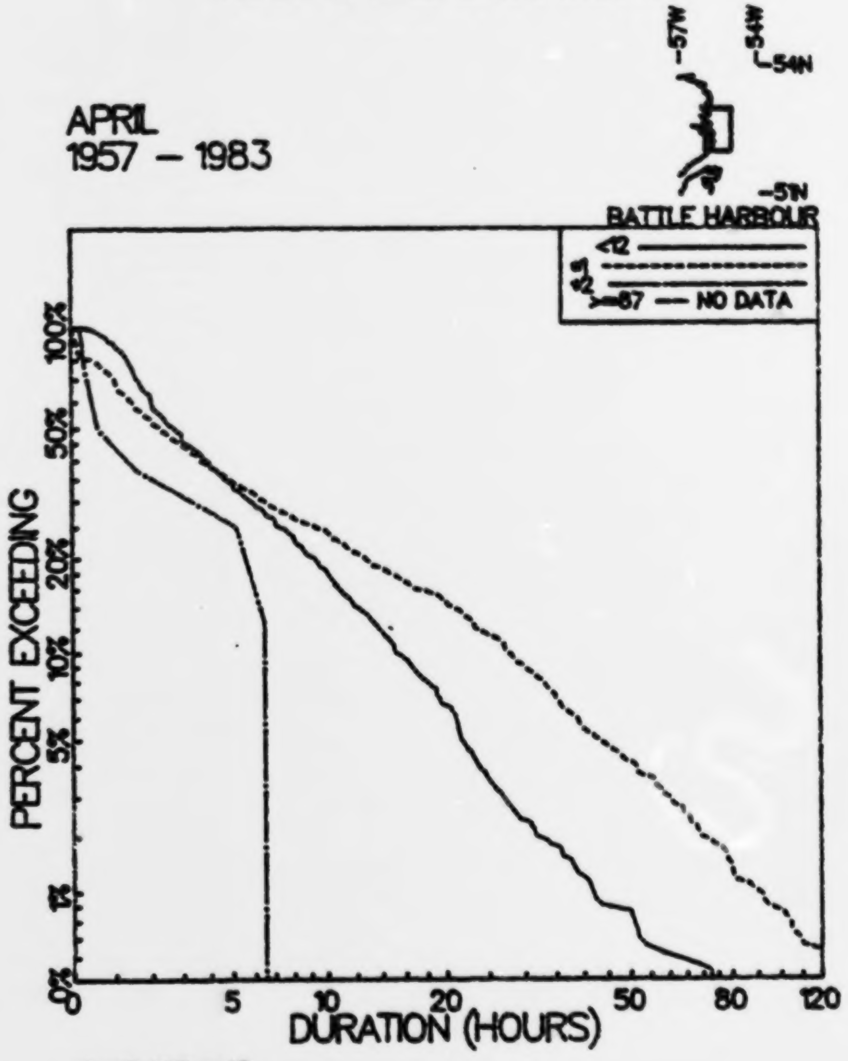
WIND SPEED DURATIONS



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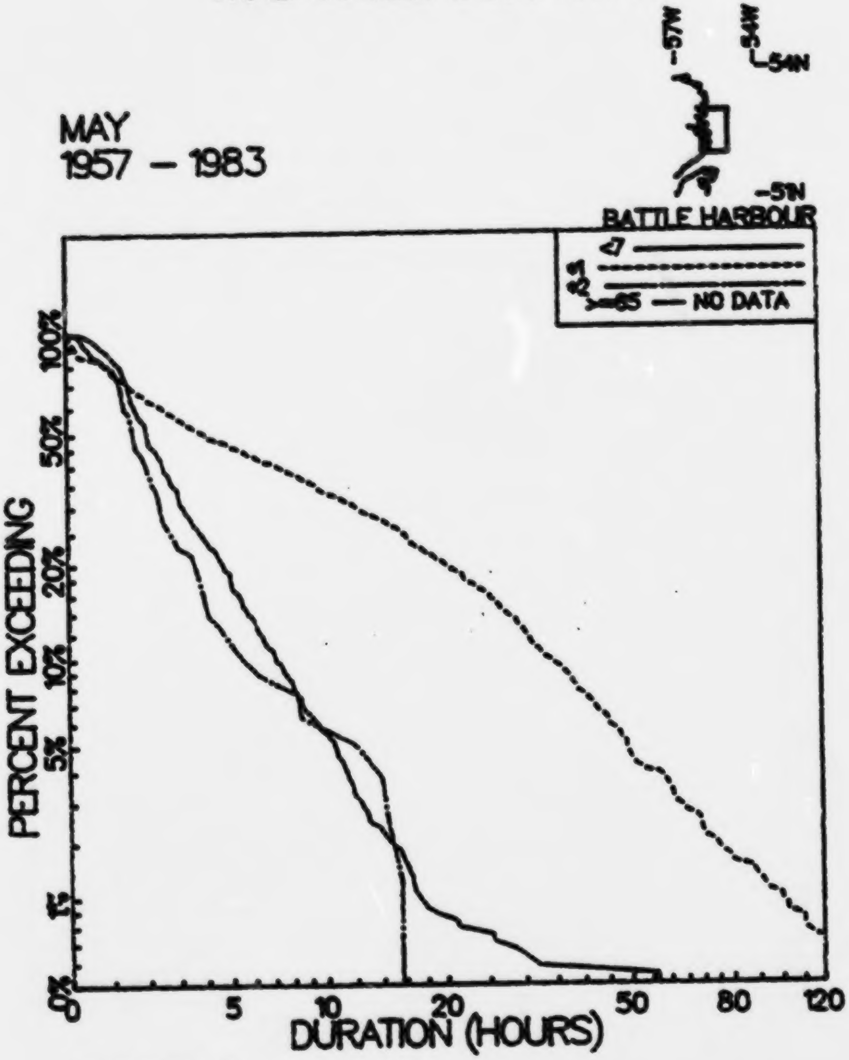
13

ENVIRONMENT CANADA
ATMOSPHERIC ENVIRONMENT CANADIAN CLIMATE CENTRE

WIND SPEED DURATIONS

MAY
1957 – 1983



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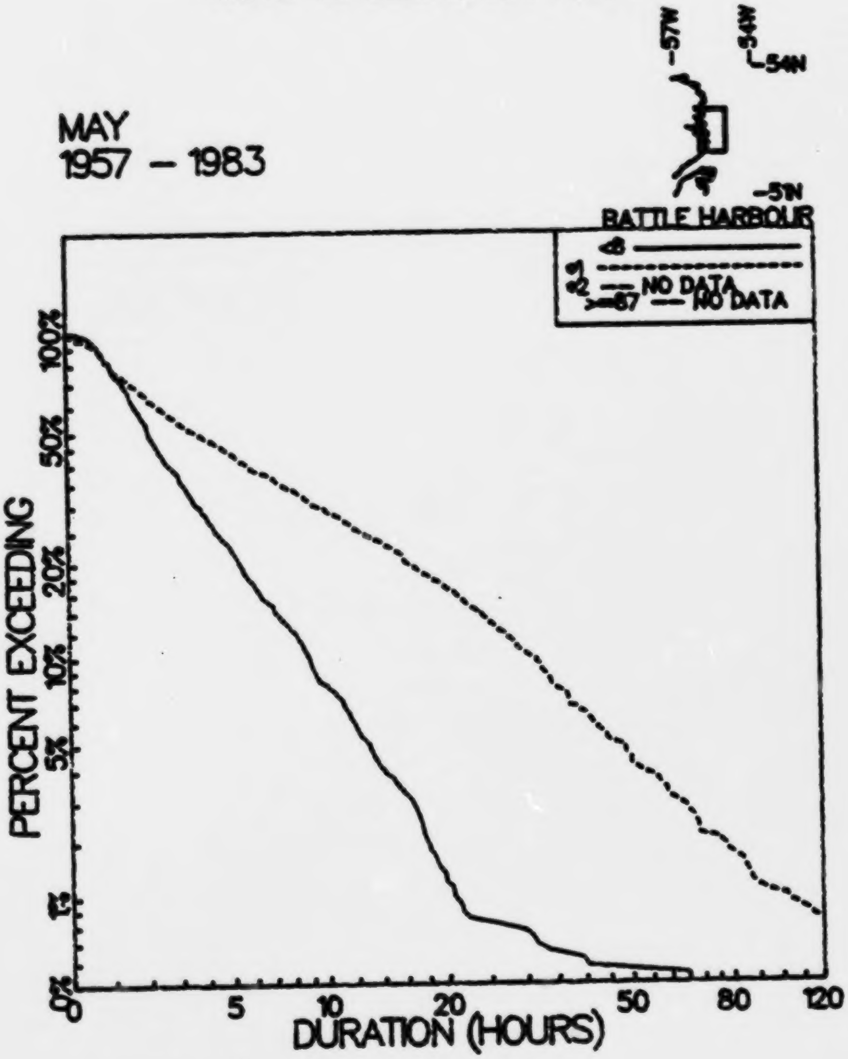
WIND SPEED DURATIONS



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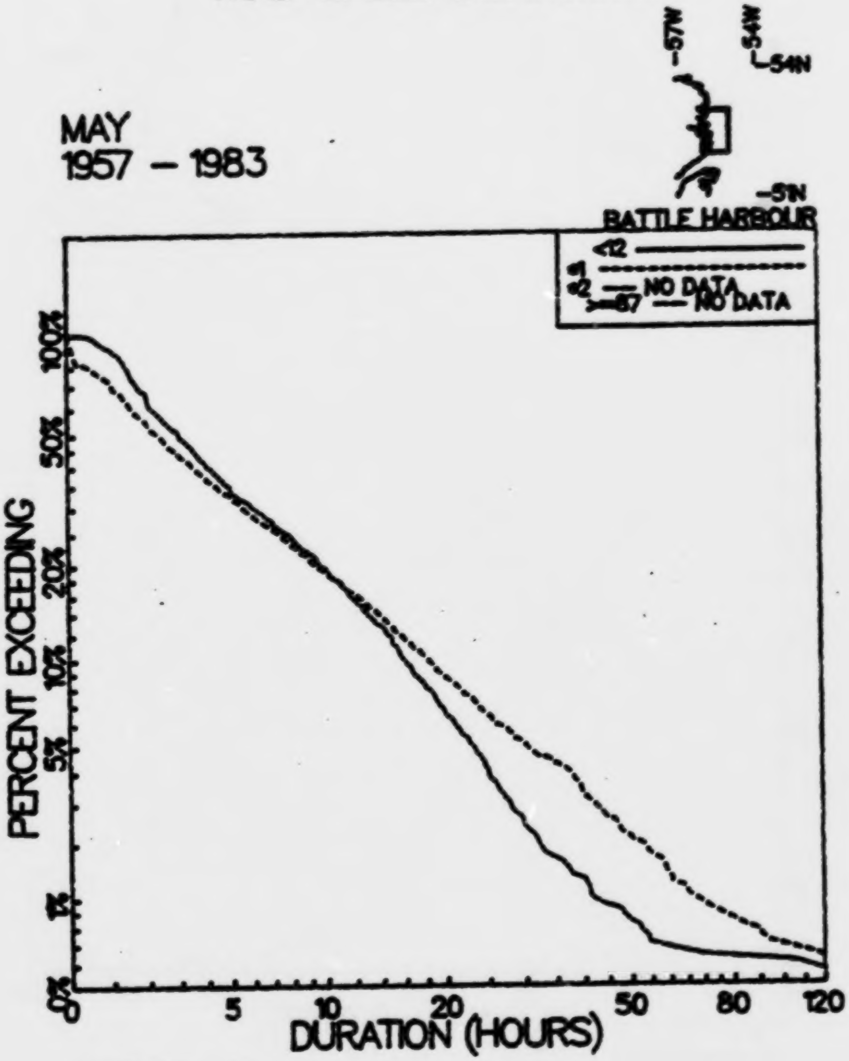
15

WIND SPEED DURATIONS

MAY
1957 – 1983



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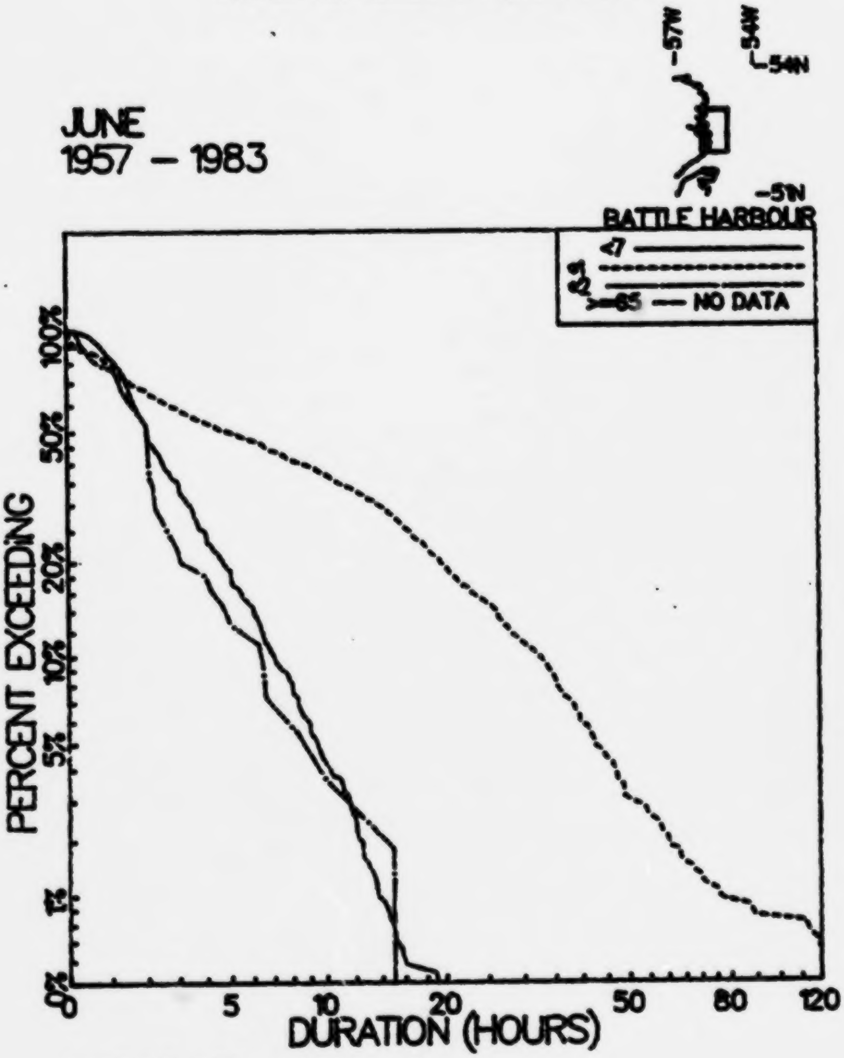
WIND SPEED DURATIONS



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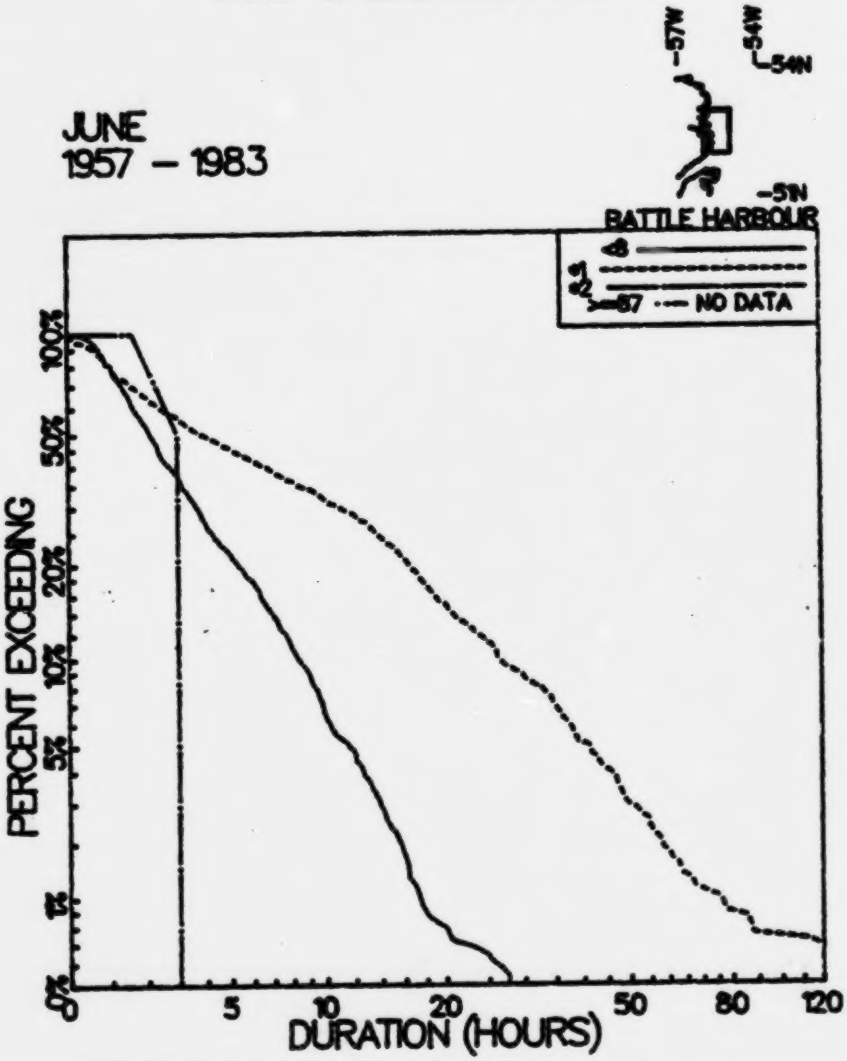
ENVIRONMENT CANADA
ATMOSPHERIC ENVIRONMENT CANADIAN CLIMATE CENTRE

WIND SPEED DURATIONS

JUNE
1957 – 1983



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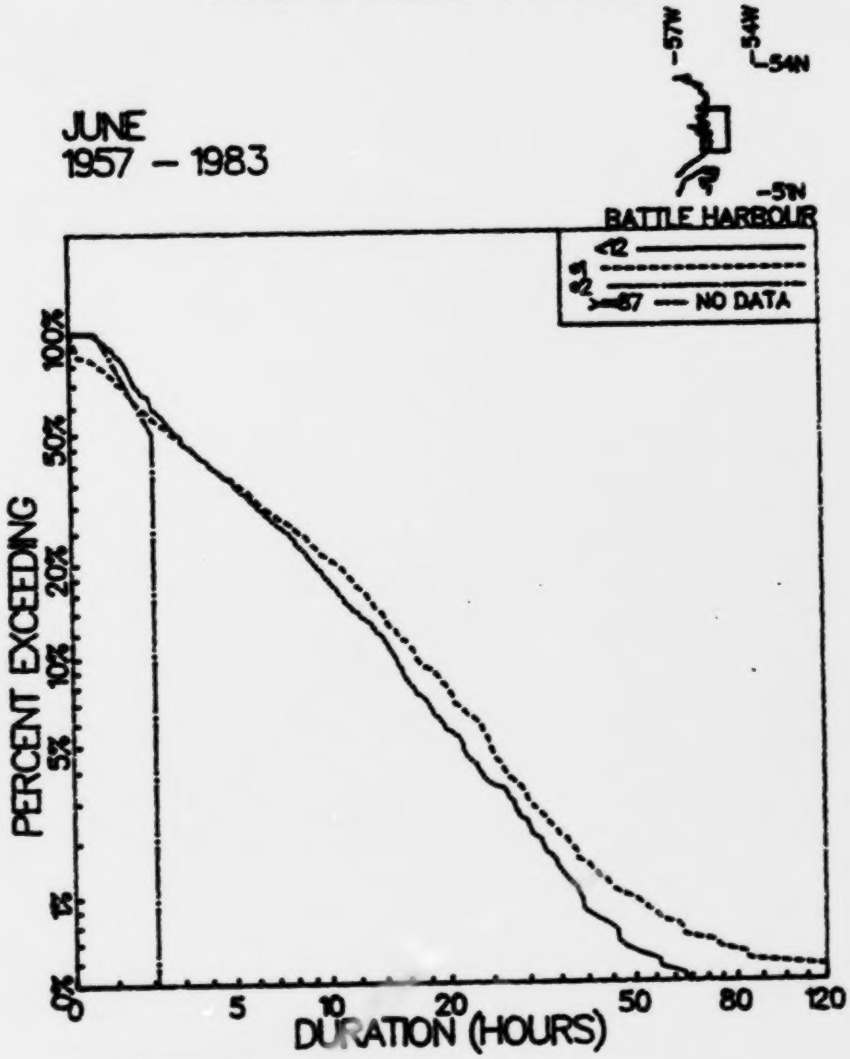
WIND SPEED DURATIONS

JUNE
1957 – 1983



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WIND SPEED DURATIONS

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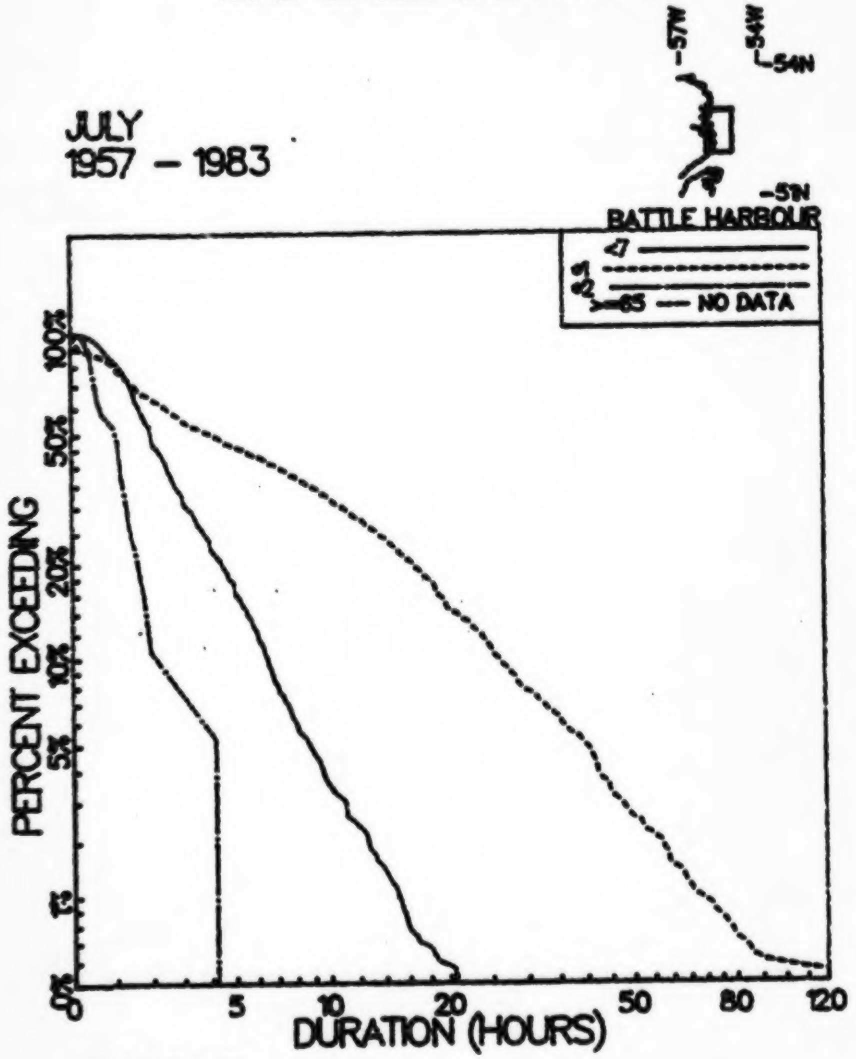
1957 – 1983



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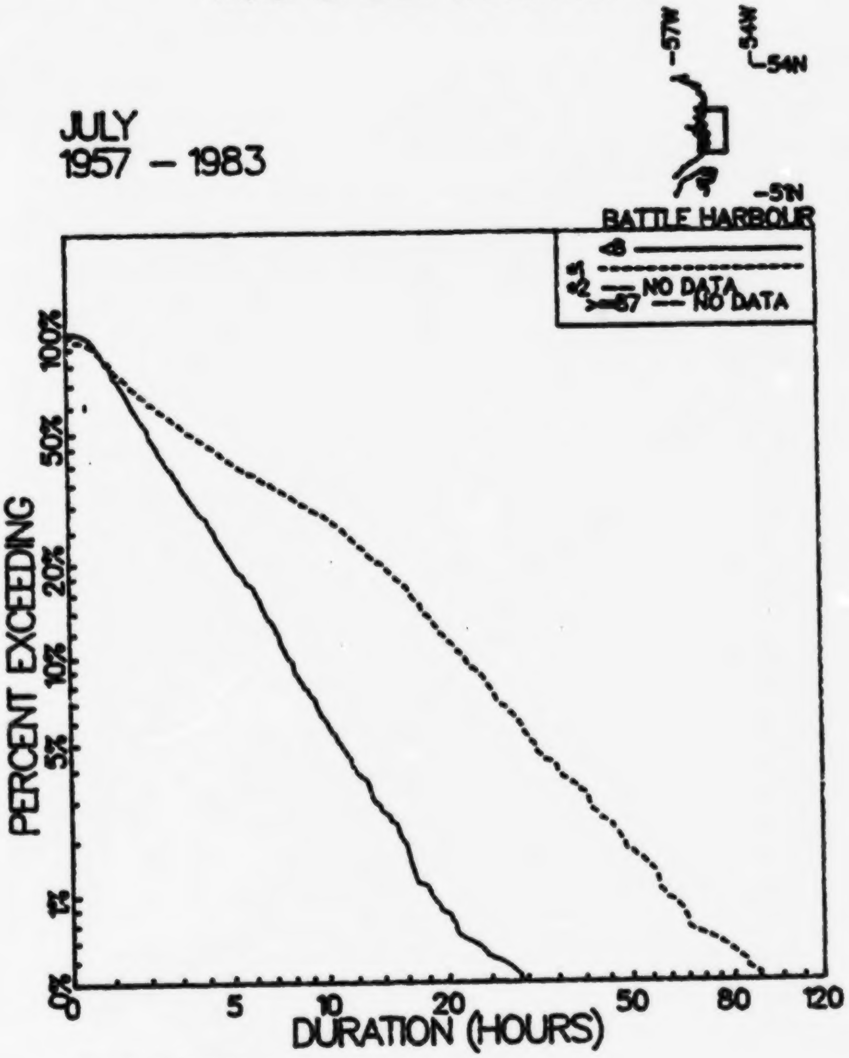
WIND SPEED DURATIONS

JULY
1957 – 1983



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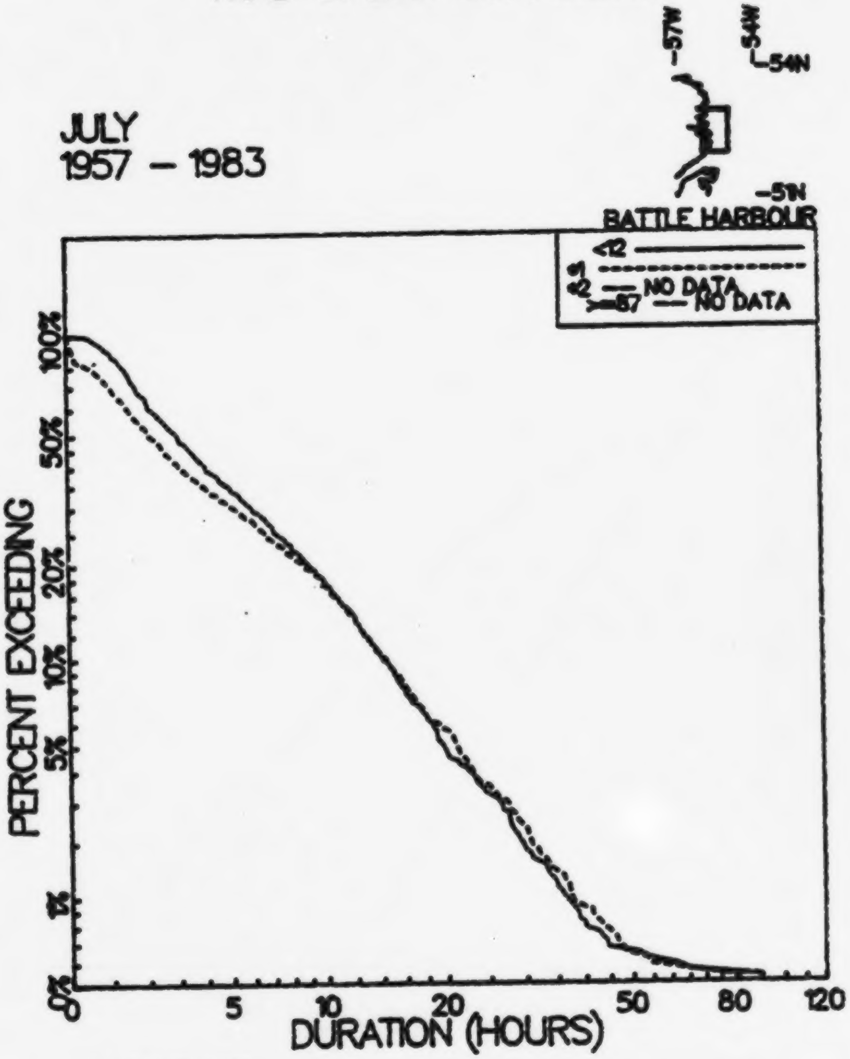
WIND SPEED DURATIONS

JULY
1957 – 1983



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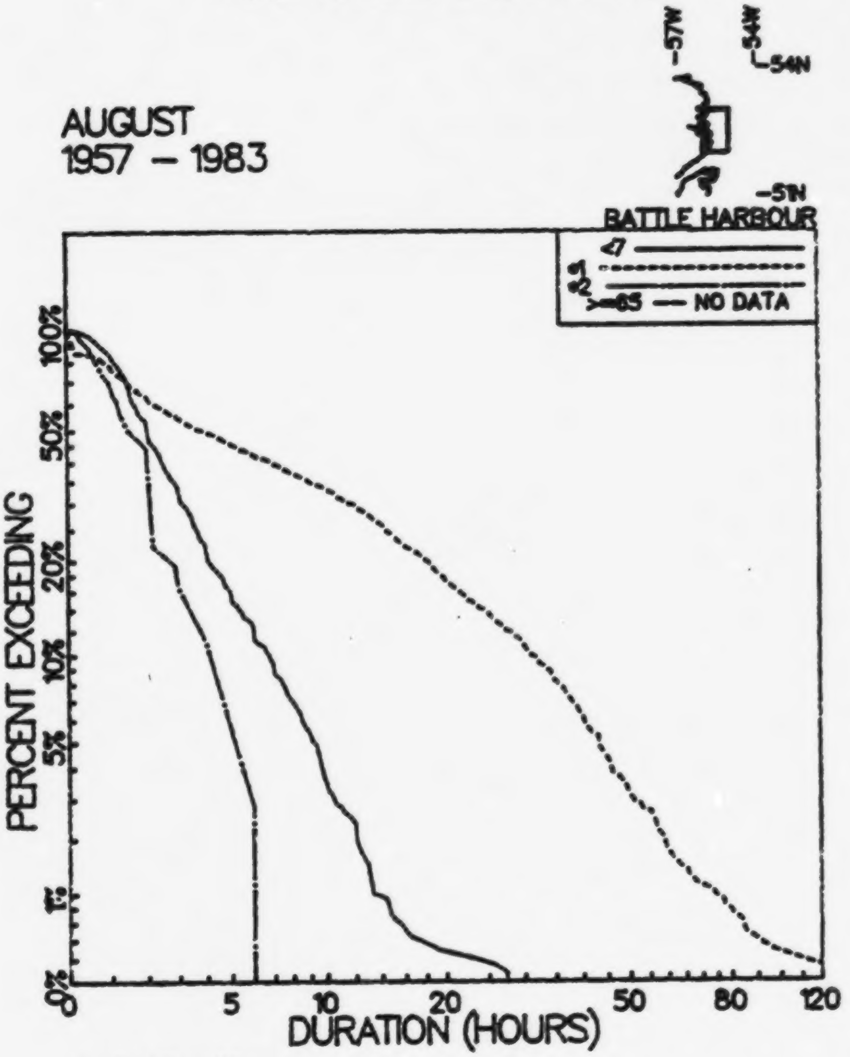
ENVIRONMENT CANADA
ATMOSPHERIC ENVIRONMENT CANADIAN CLIMATE CENTRE

WIND SPEED DURATIONS



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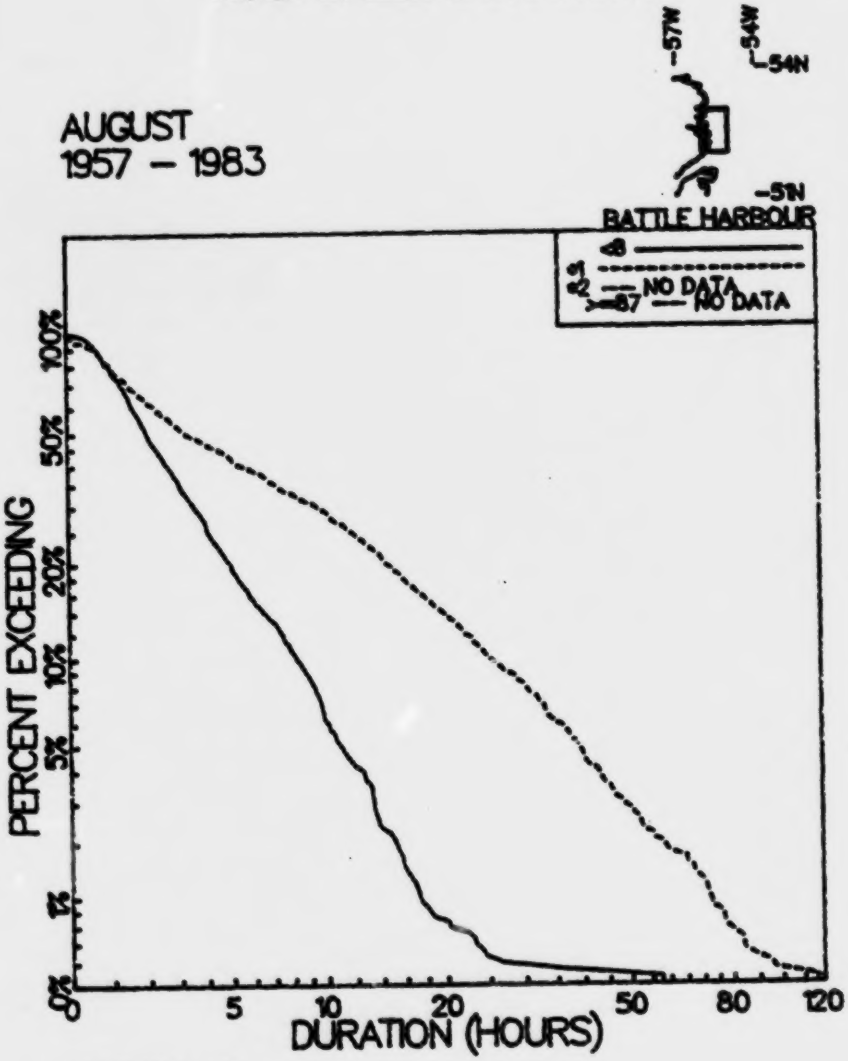
23

ENVIRONMENT CANADA
ATMOSPHERIC ENVIRONMENT CANADIAN CLIMATE CENTRE

WIND SPEED DURATIONS

AUGUST
1957 – 1983



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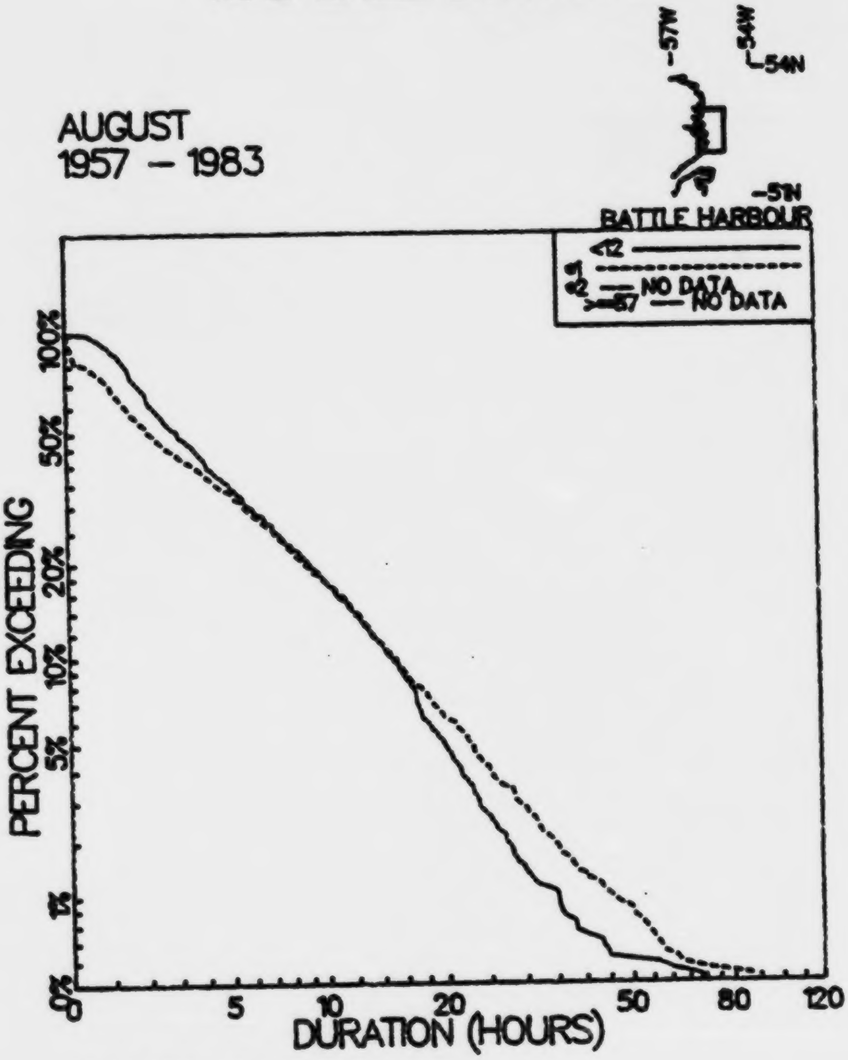
ENVIRONMENT CANADA
ATMOSPHERIC ENVIRONMENT CANADIAN CLIMATE CENTRE

WIND SPEED DURATIONS

AUGUST
1957 – 1983



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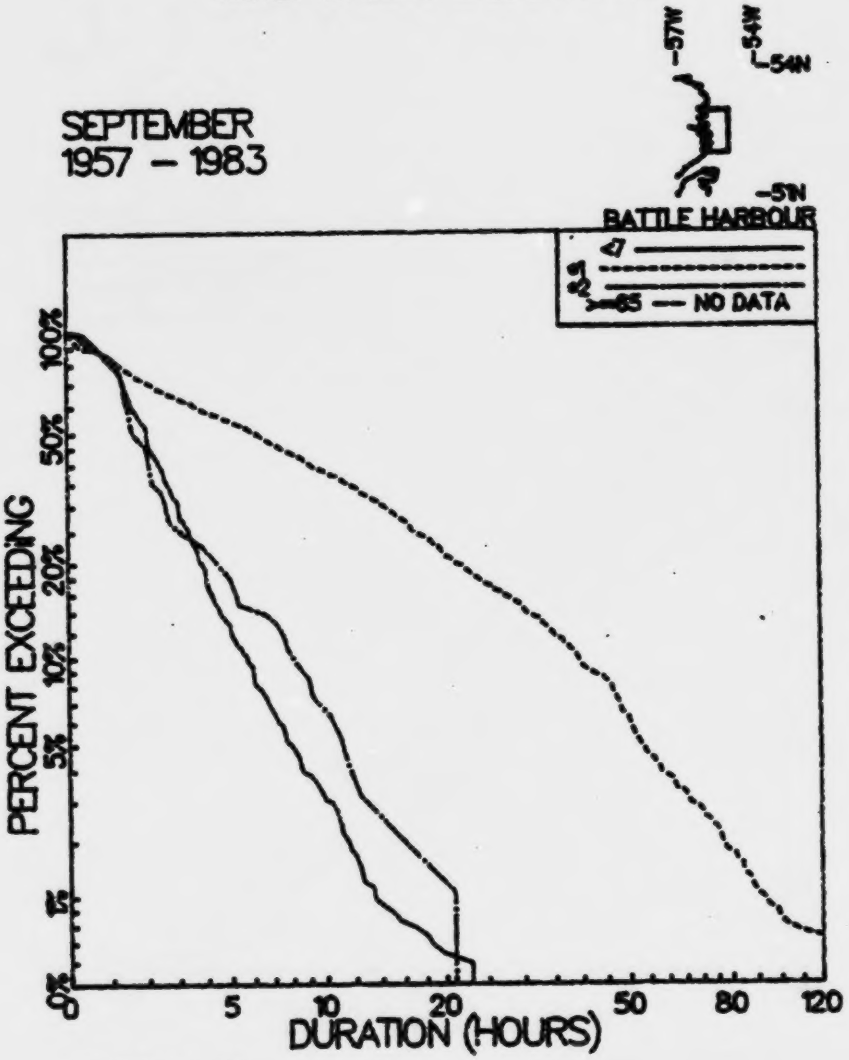
25

ENVIRONMENT CANADA
ATMOSPHERIC ENVIRONMENT CANADIAN CLIMATE CENTRE

WIND SPEED DURATIONS

SEPTEMBER
1957 – 1983



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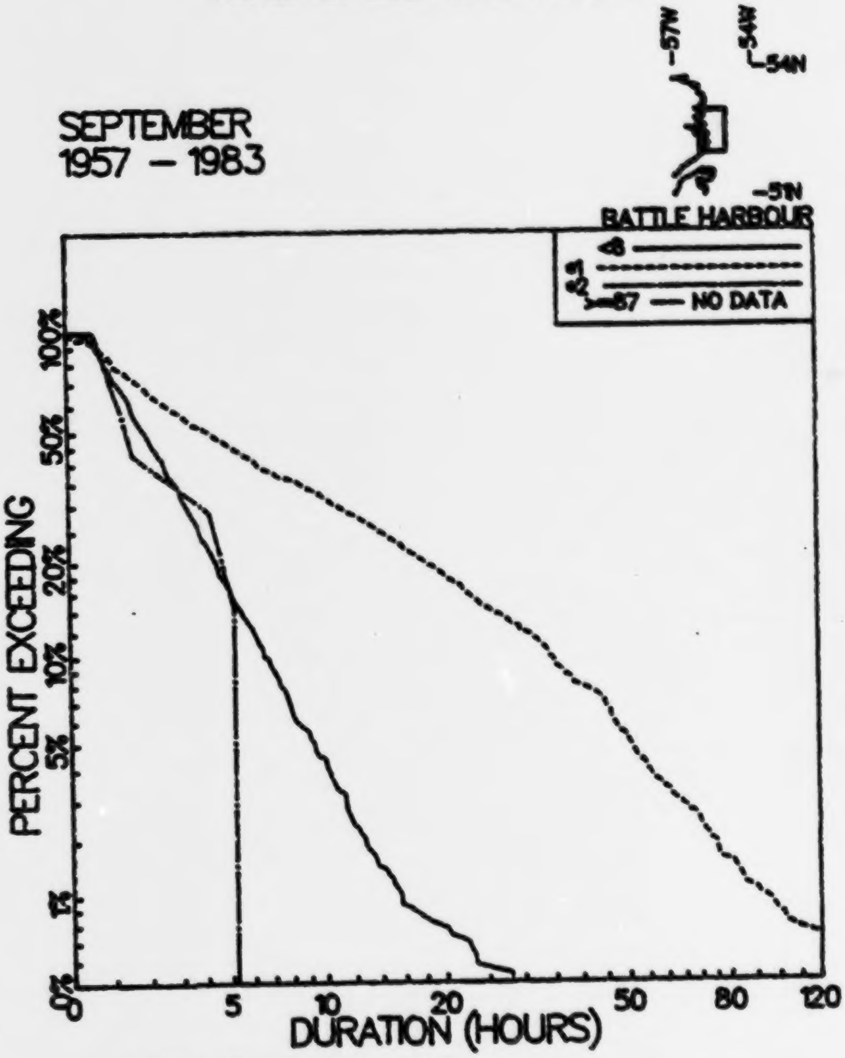
WIND SPEED DURATIONS



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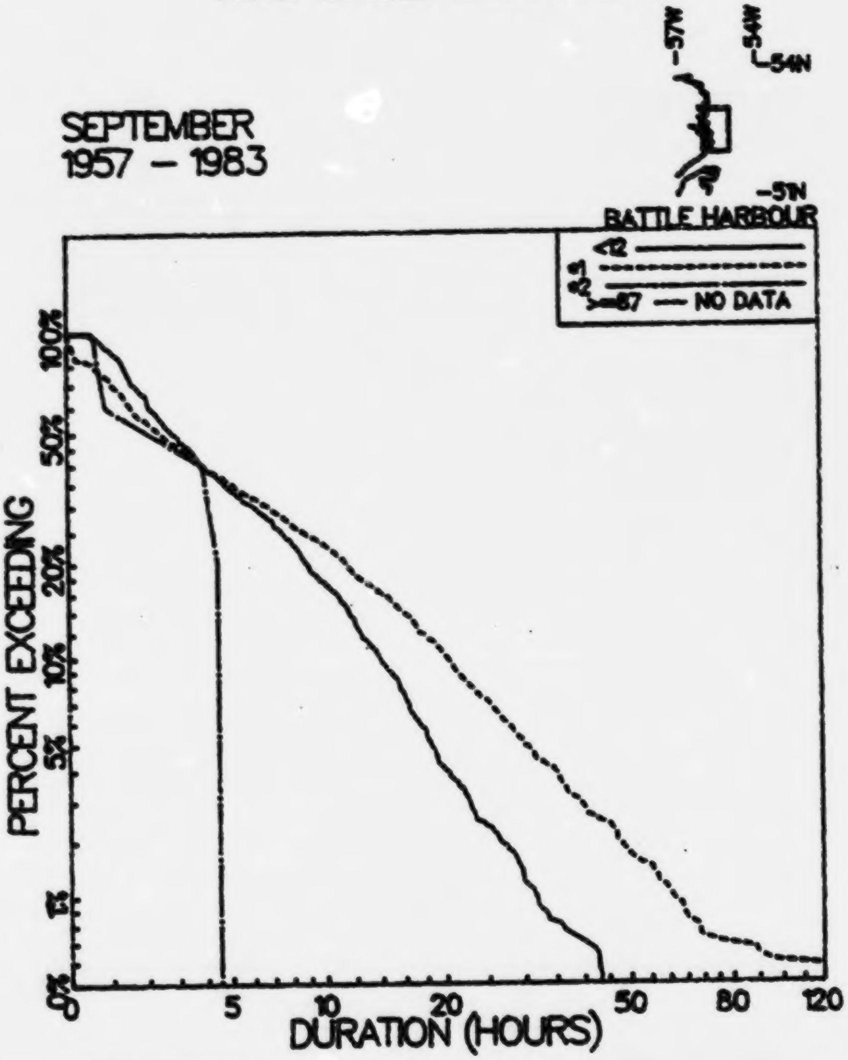
WIND SPEED DURATIONS

SEPTEMBER
1957 – 1983



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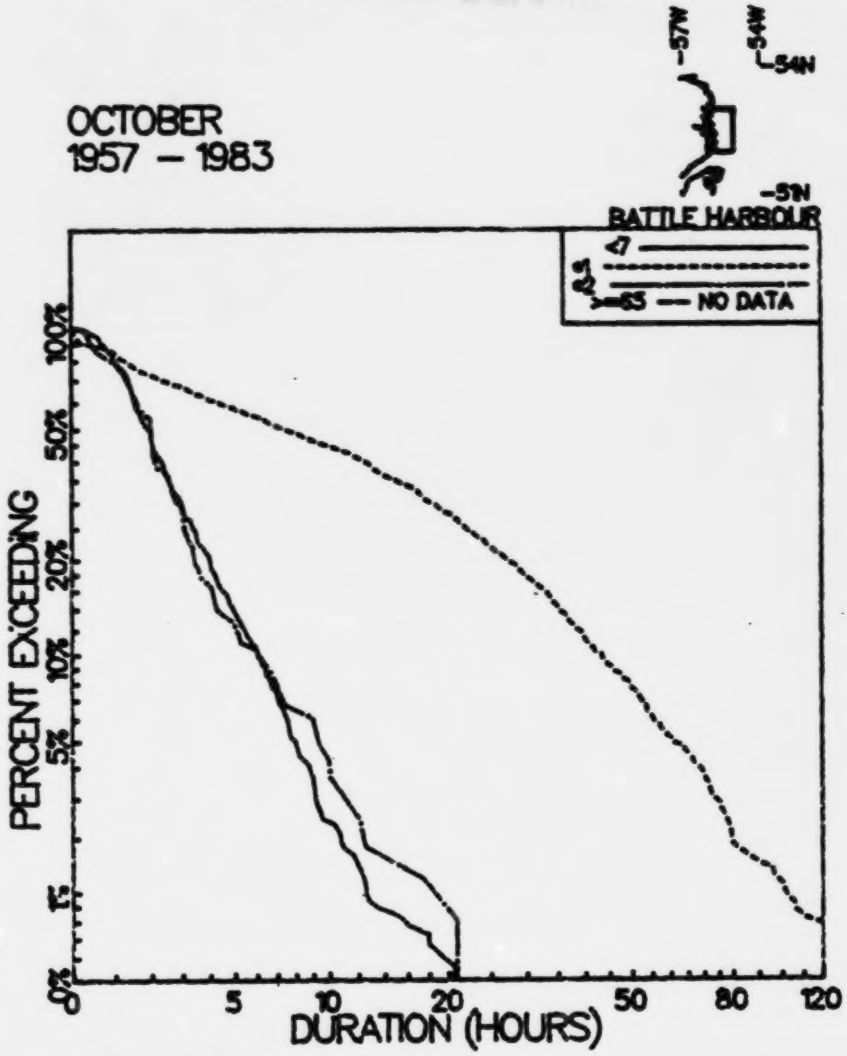
WIND SPEED DURATIONS



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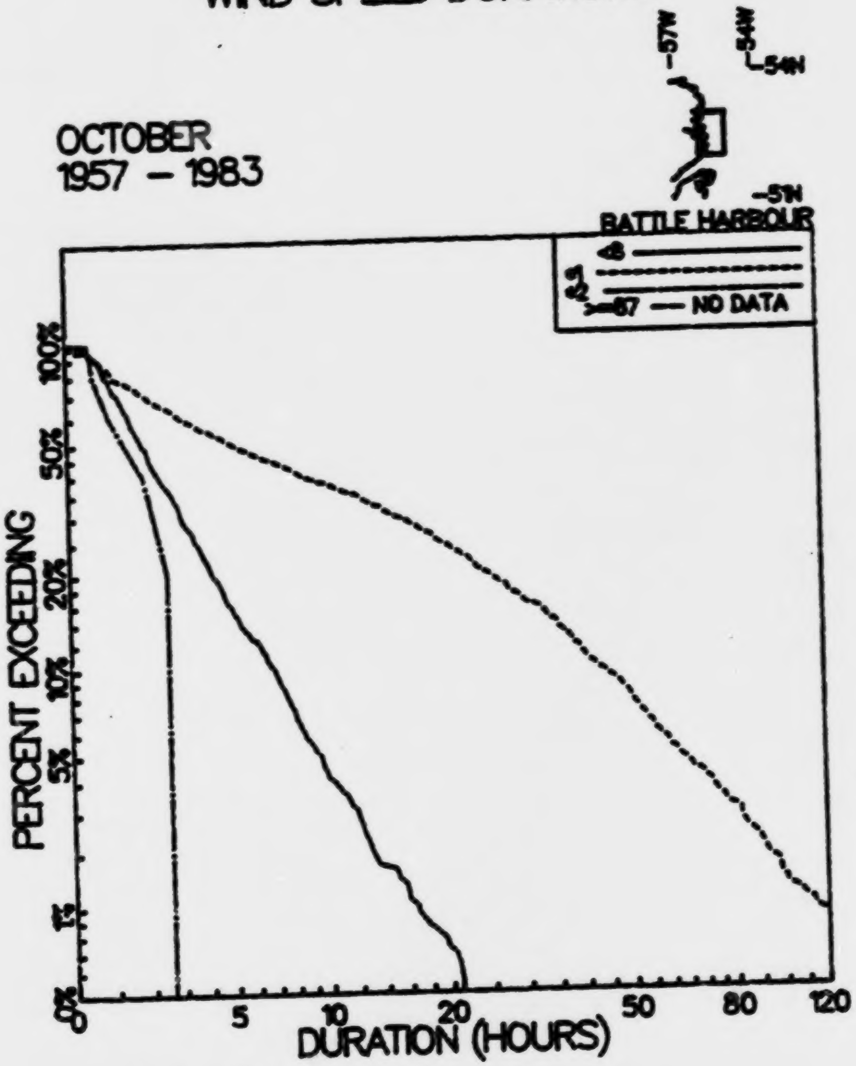
ENVIRONMENT CANADA
ATMOSPHERIC ENVIRONMENT CANADIAN CLIMATE CENTRE

WIND SPEED DURATIONS

OCTOBER
1957 – 1983



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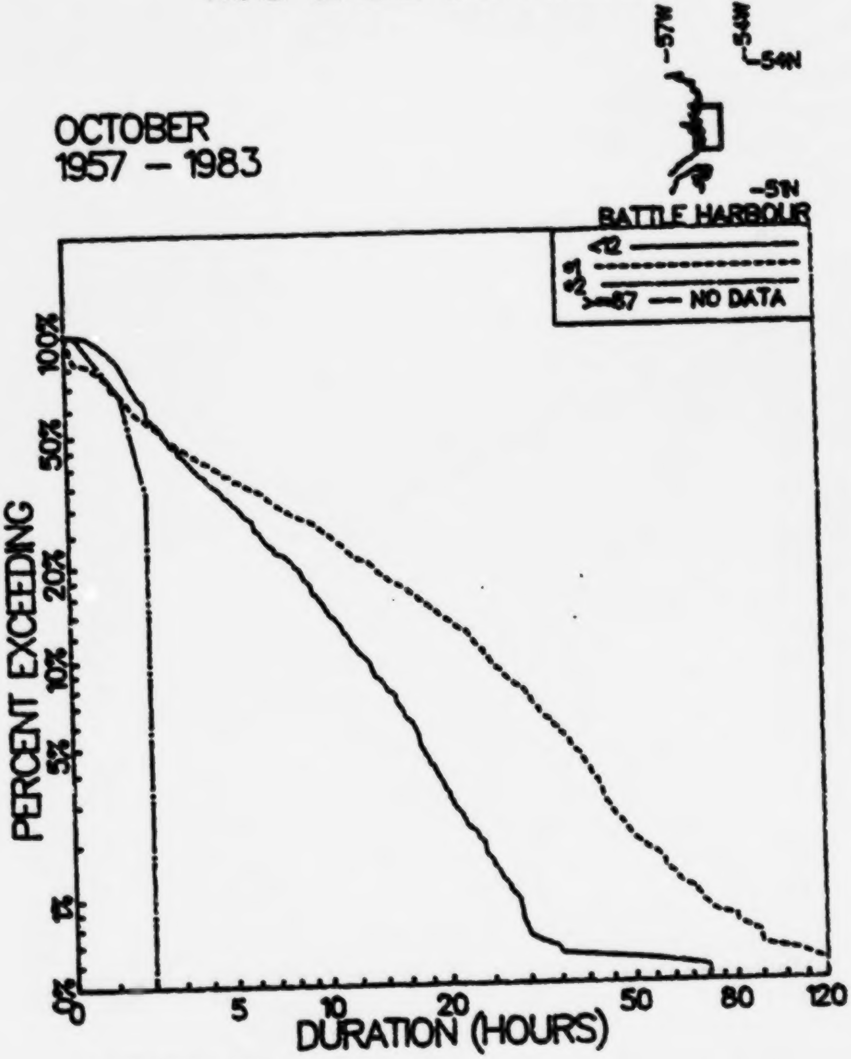
WIND SPEED DURATIONS

OCTOBER
1957 – 1983



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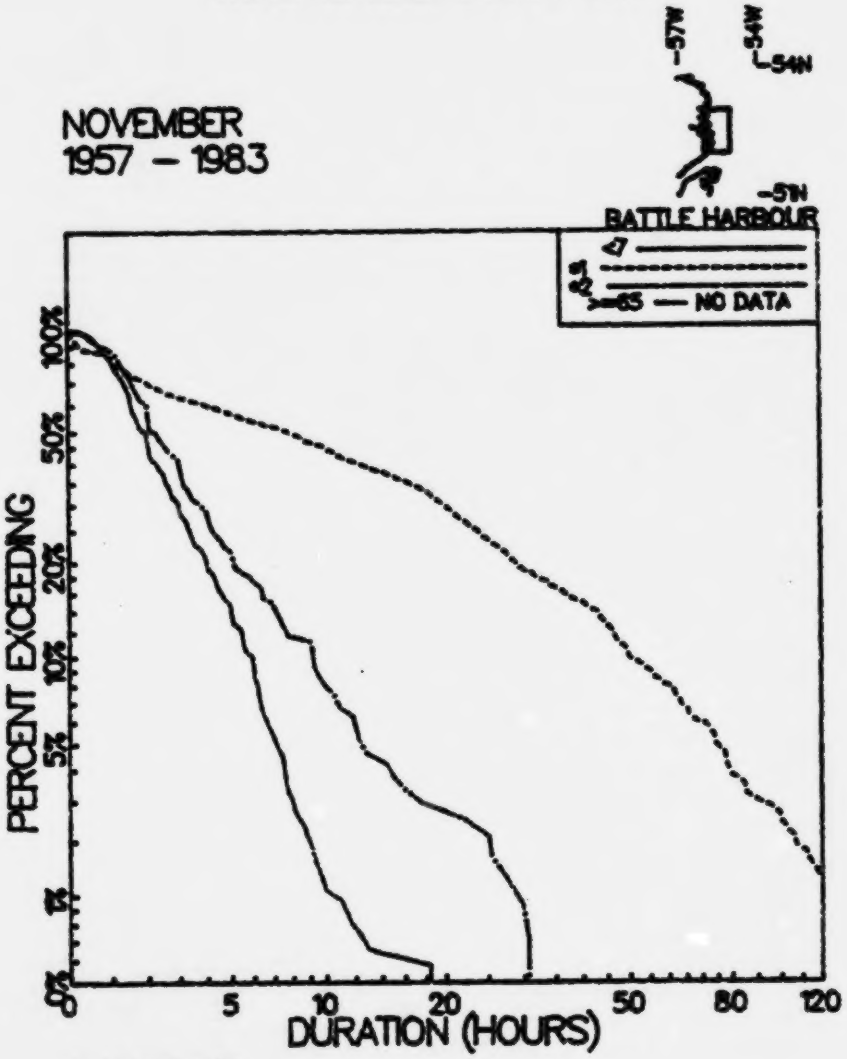
31

WIND SPEED DURATIONS



NOVEMBER
1957 – 1983

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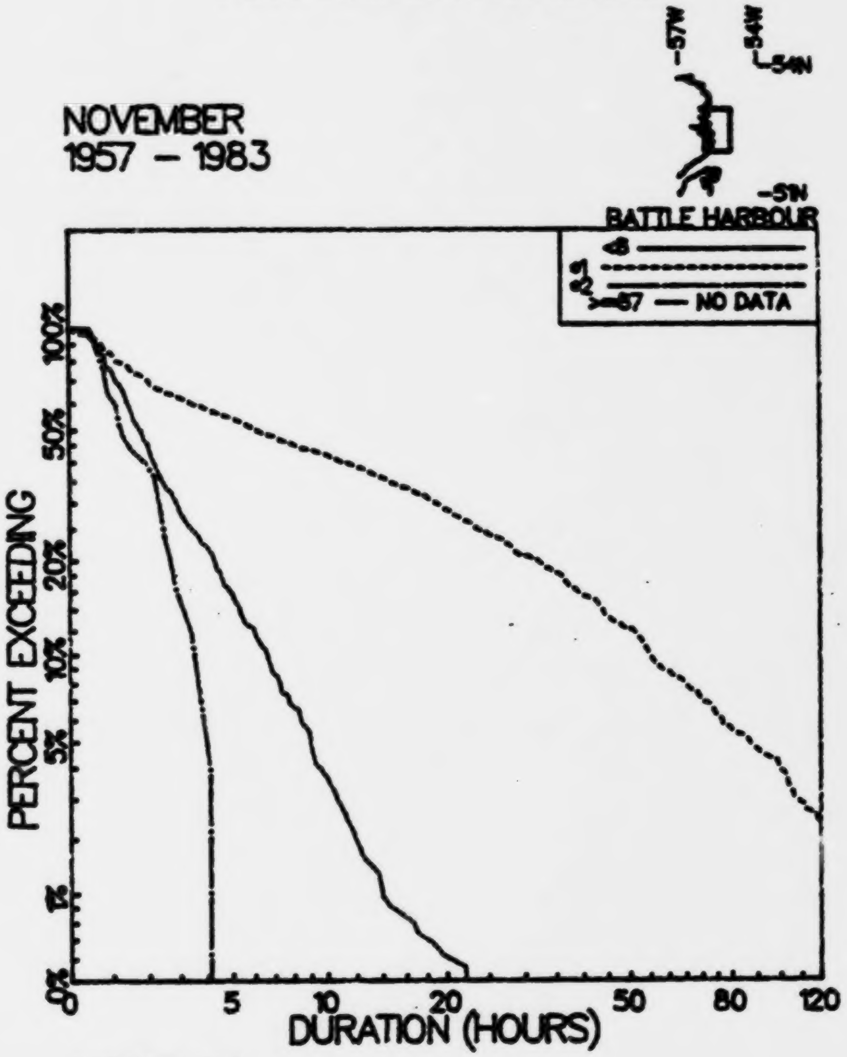
WIND SPEED DURATIONS

NOVEMBER
1957 – 1983



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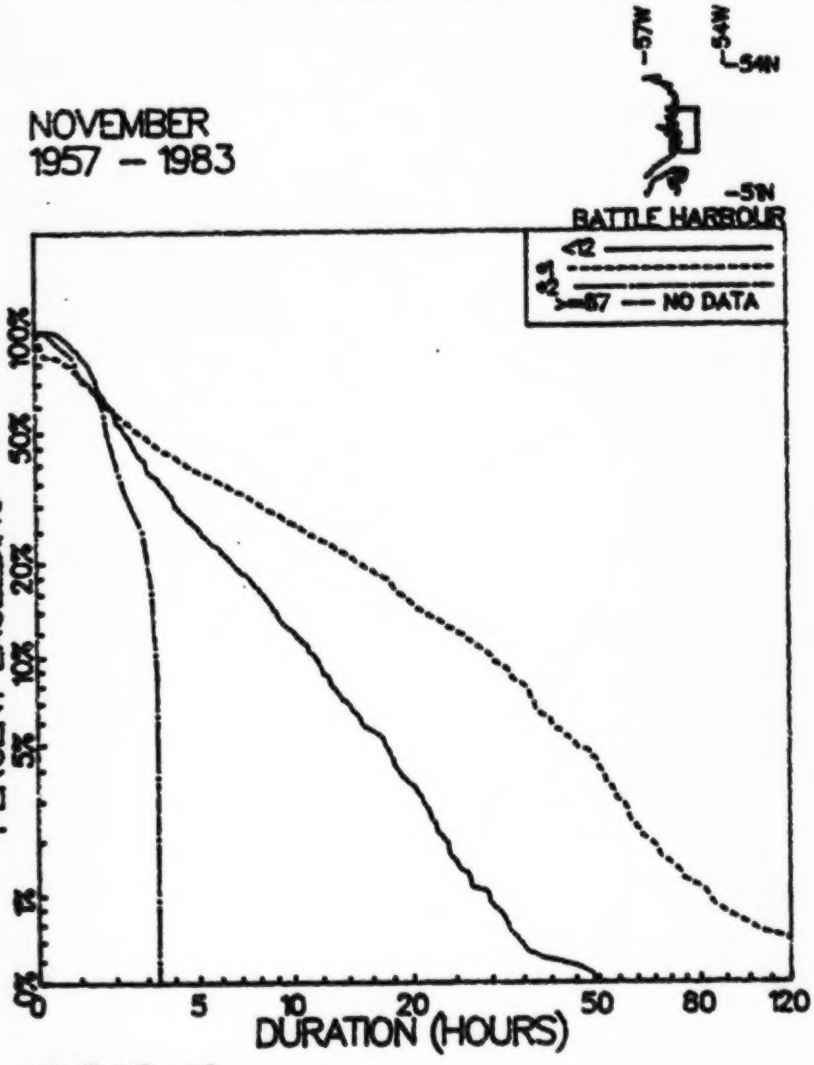
ATMOSPHERIC ENVIRONMENT CANADIAN CLIMATE CENTRE

WIND SPEED DURATIONS



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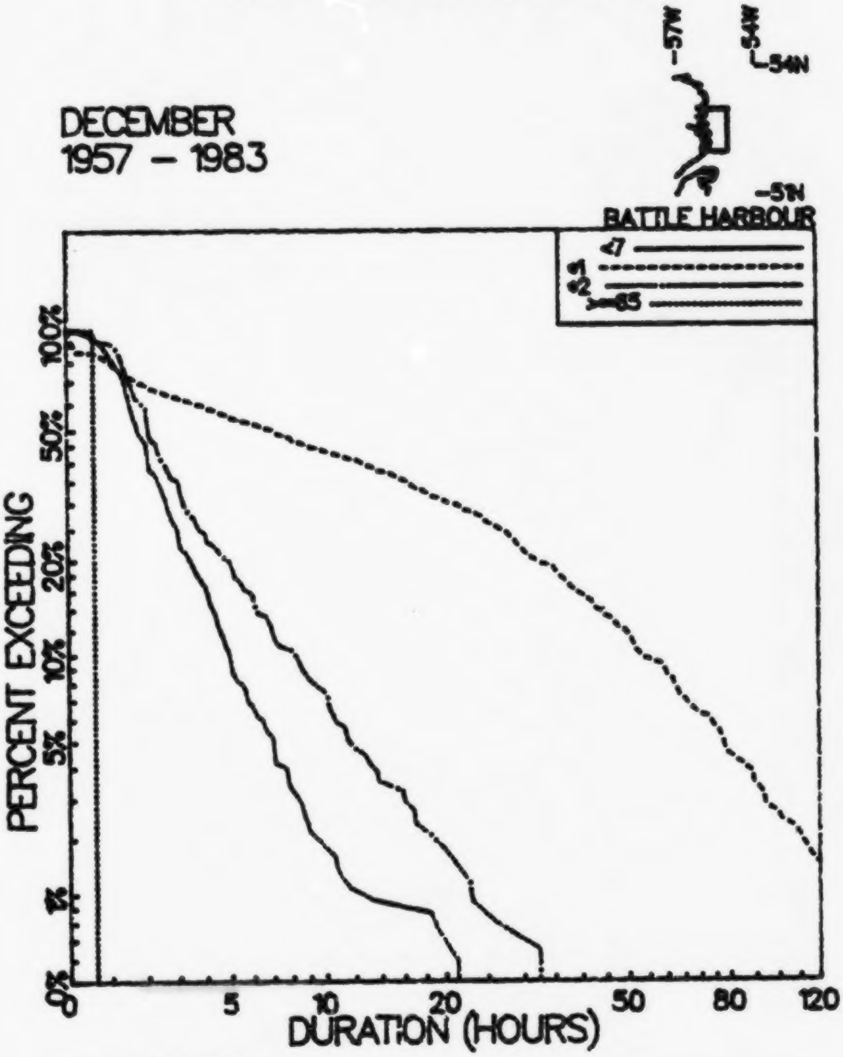
WIND SPEED DURATIONS



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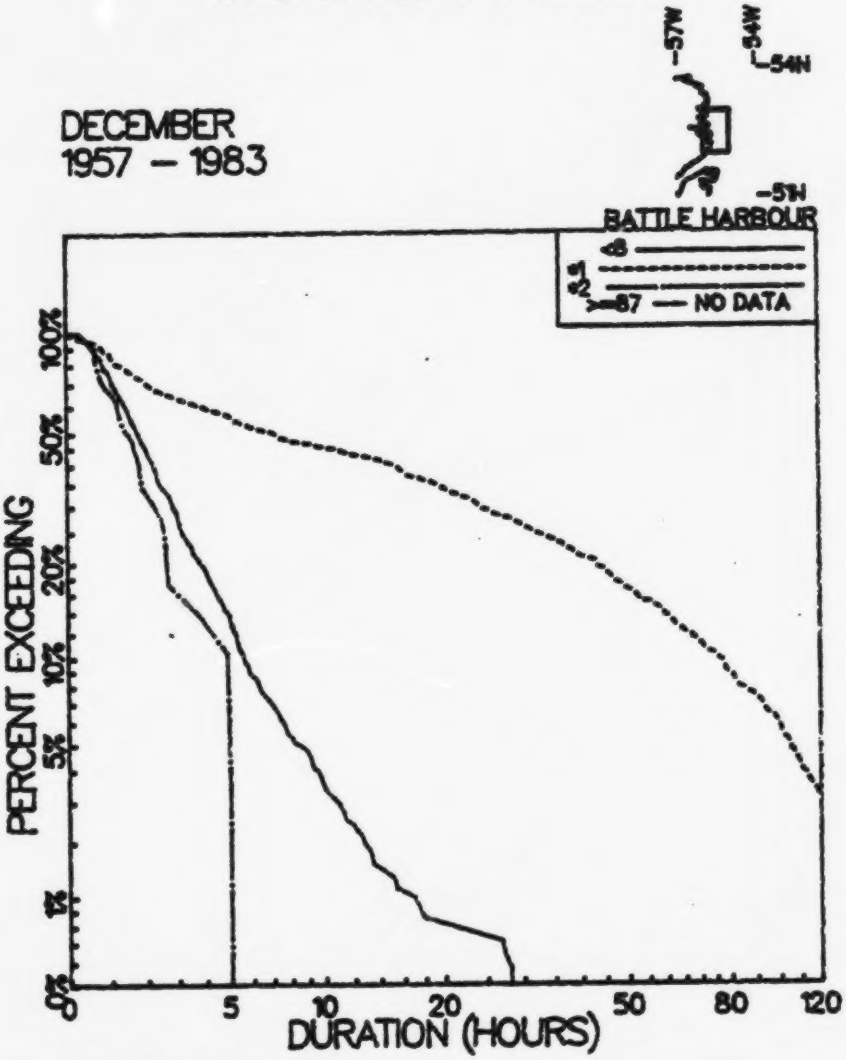
WIND SPEED DURATIONS

DECEMBER
1957 – 1983



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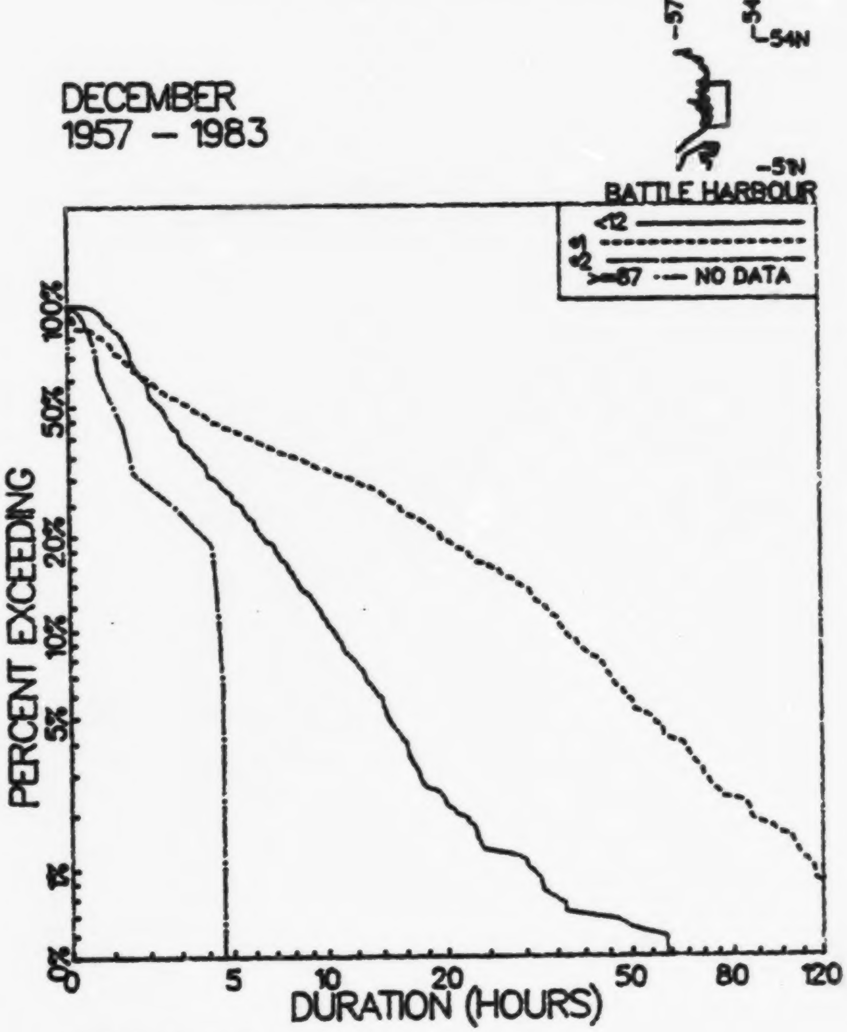
36

WIND SPEED DURATIONS

DECEMBER
1957 – 1983



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Appendix 3.0

Technical Data

3.1 Mechron Ltd. quotation and general information

3.2 Jacobs maintenance and other information

3.1 Mechron Ltd. quotation and general information

MECHRON

Mechron Energy Ltd.
2437 Kaladar Avenue
Ottawa, Canada K1V 8B9
(613) 733-3855
Telex. 053-4271

RECEIVED
SEP 18 1984
PROVINCIAL
CONSULTANTS
LTD.

September 11,1984

Provincial Consultants,
P.O. Box 13068,
St. John's, Newfoundland.
A1B 3V8

Attention: David C. Stewart, P. Eng.

Reference: Hybrid Cycle Charge® for Southcoast, Labrador

Dear Sir:

We are pleased to respond to your letter of August 7, as follows. As discussed, it has not been practical to prepare a full proposal. We are submitting data which will enable you to conduct your study.

Also, as discussed, we suggest that a demonstration be run in two phases:

- Energy-conserving diesel
- Wind (or PV) enhancement

I Cycle Charge System 4000 (AC Version)

a) Budgetary prices are given on the enclosed pages.

b) System design philosophy and block diagram are given in the enclosure, System Design for Diesel Renewable Hybrid Power.

c) Cycle Charge brochure enclosed.

II **PV-Hybrid**

As discussed, we suggest this alternative may not be economically viable. A rule-of-thumb installed cost, not including batteries, of $17. per peak watt or $170. per average watt in Canadian sites with good insolation may lead you to a conclusion.

III **WTG-Hybrid**

We have enclosed the letter dated 20 August, and price sheets from Jacobs Wind Electric. You agreed you would ask Terra Nova Marine to convert the U.S. prices to Canadian, including installation.

IV **Life Cycle Costs**

a) We gave you a copy of a study which gives capital, operating and maintenance cost data for a typical (about 15 KW) conventional diesel and Cycle Charge diesel.

b) We are doing an NRC-funded study of wind/cycle charge hybrid life cycle costs vs. conventional diesel. When we have preliminary results we can let you know.

c) As discussed, we believe we have provided sufficient data for you to do the analysis.

In conclusion, if you have more questions, please call us.

If you want us to check your calculations we would be pleased to do so.

Yours truly,

John Dure

J.D. Dure
Vice President

Encl:

JDD/dl

BUDGET PRICES FOR C/C 4000

		10 KW	20 KW	30 KW	45 KW	60 KW	75 KW	100 KW	125 KW	150 KW
1.	4000/DG Set & Controls	81,000	87,000	93,000	103,000	108,000	116,000	124,000	130,000	138,000
2.	Min. Battery	8,400	17,650	32,000	48,000	55,000	65,000	90,000	98,000	147,000
3.	Insulated, Vented Power Bldg.	20,000	20,000	24,000	24,000	28,000	28,000	30,000	30,000	30,000
4.	Standby Diesel (Bare)	12,000	14,000	16,000	17,000	19,000	21,000	24,000	28,000	31,000
5.	Increase for Enclosure Length for New Standby Diesel	8,000	8,000	10,000	10,000	10,000	10,000	12,000	12,000	12,000
6.	Increase for Heat Recovery for Existing Standby Diesel	---------------------- Subject to Site Visit ----------------------------------								

SYSTEM DESIGN FOR

DIESEL/RENEWABLE HYBRID POWER

29 May, 1984
Rev. 10 Aug. 1984

INTRODUCTION

Hybrid power systems which use renewable energy in combination with energy-efficient diesels under microprocessor control and integrated into a building are seen by Mechron as the ultimate package in energy-efficient power for remote unattended sites and small settlements where a high degree of reliability is essential.

The combination of a diesel genset with a renewable-energy source results in radical downsizing of battery, PV array and structure or WTG and tower. The diesel system can carry the load under worst-case conditions of load or climate and can be integrated into a thermodynamically-efficient package. The renewable-energy source can be downsized to carry the average load.

Traditional practice has been to overdesign power systems, resulting in uneconomic operation and maintenance. Today, efficient system design will minimize the costs of capital, fuel and maintenance to shorten the payback period.

Mechron is a power-systems integrator with versatile capabilities in design, production, installation and service of renewable and fuel-driven energy sources. Disciplines include mechanical, electrical, electronic and thermodynamic design. Power packages are produced which are specific to the customer's needs.

LOAD DEMAND

A key parameter needed for good design of a small, efficient power system is the Load Duration Curve. The short-term (about 3-second) peak load is important, since this peak power must be supplied by the source.

Figure 1 shows a load demand for a small community over a 24-hour period. The peak-hour load exceeds the average load by about 5:1. Short-term peaks, caused by starting of inductive loads shown in Figure 2, can result in a peak-to-average ratio of about 15:1. The smaller the settlement, the larger this ratio is likely to be.

If the community has seasonal load variations, these can result in further shifts in both peaks and average loads.

© Prepared by: John D. Dure, Vice-President, Mechron Energy Ltd., Ottawa
(613) 733-3855

Site or community load data is difficult to obtain, yet it is necessary for accurate design. Measurements for communities are rare and those that do exist are typically made by readings from a 15-minute-averaging thermal-demand meter. The short-term peaks are obscured.

Consequently, past practice has been to oversize generating systems. This results in low overall efficiency and high costs of capital, operations and maintenance.

Figure 3 shows a sample load calculation for a remote unattended communications site. Typically, the essential, continuous radio load is 380 to 1000 watts. The example is for a 24 VDC, 750 watts load. This would require a 31 amp rectifier so the designer chooses the next higher standard size, 50 amp, and two for redundancy. Already the peak load is 2800 watts! Following down the sample calculation, there is need for fans, heaters, lighting, etc. so the radio room load becomes 8,640 watts. Adding up the diesel room load for rectifiers, fuel pumps, fans, heaters and lighting adds 2.7 KW. The result is that most remote radio sites are powered by a dual-redundant, 10 to 15 KW diesel genset running full-time. Much of the parasitic or intermittent load can be reduced by rearrangement of the loads and better system layout in the site building.

The variation of load demand vs. time needs to be identified over a 12-month period. This can be derived in several ways, typically by a combination of measurement, personal survey, load analysis and estimation of the peaks. This data can be analysed and plotted as a Load Duration Curve (Figure 4) which shows power level versus percent time equalled or exceeded. Four hypothetical curves are shown. The peak-to-average ratios are inverted and shown as Load Factor = Average ÷ Peak Power.

Load Factors of .67 to .5 could be typical of cities. Factors in the range .2 to .05 are what we encounter in communications sites and small settlements.

Many users do not really know their load characteristics and some claim that their Load Factor is one!

ENERGY SUPPLY

The theme here is, what happens when supply does not equal demand?

The ideal energy source would be tolerant to peak overloads, operate at high efficiencies over a wide dynamic power range, withstand extremes of temperature, provide stable voltage and frequency, have low harmonics, and be highly reliable with low maintenance. The utility power grid meets these criteria well. Independent power sources do not.

The quality of power and the availability required by the user are important. Typically, these characteristics include constant voltage (±5%), availability greater than 99.7%, and if AC is required, frequency regulation of 1/2 to 3 Hz plus distortion less than 5%.

- Diesel Genset: (Figure 5A)

The diesel-generator has the capability to deliver continuous, reliable power and is tolerant to overload abuse. It can, typically, deliver 350% rated power for a second or two (thus it can blow a fuse or trip a breaker under short-circuit conditions) and 110% for an hour. Ideally, when fully loaded, it can produce 3.3 to 4.3 KWH per litre but this can fall to about 2.2 KWH per litre under light loads. When a diesel is loaded to less than 40%, it will run inefficiently, carbon up and require high maintenance or be prone to failure. One operating practise is to insert a dummy load or run a parasitic load (street lights 24 hrs. a day), to load the diesel.

If a peak overload occurs (Figure 5A), the genset will shut down. One design strategy is to start, parallel and stop two or more diesels in accordance with the anticipated load peaks (Figure 6). This strategy tends to fail because the peaks cannot be accurately predicted, especially if there are a few large loads. The human operator will tend to minimize shutdowns on peaks by operating the system full-time at maximum capacity. A computer-controlled system can improve the system availability. Random shutdowns of 30 to 60 seconds will occur while the computer sheds load and restarts a genset of adequate size.

Conventional diesels will start reliably at temperatures above 5°C and in-service results have shown that unattended sites have an availability of 99.97%.

To operate over a wide temperature range, diesel gensets must normally be 'packaged' with appropriate venting and heat-conservation.

Under contract from Transport Canada/Coast Guard, Mechron has developed a modified diesel which starts reliably down to -40°C. The design is proven for an 8 1/2 KW diesel and can be extended to 30 KW. The intended application is PV/diesel hybrids for navigation aids.

- Photovoltaic System: (Figure 5B)

The PV energy supply does not meet the demand of continuous loads. Accordingly, energy storage (such as batteries) are accepted practice.

Stored battery energy can be converted to AC by either a DC motor driving an AC generator or by a static inverter. Rotary converters will tolerate short-term overloads better than static devices. The inverter must handle the peak load, yet will be running lightly loaded most of the time. Efficiency at light loads is important for good design. The inverter should not require air conditioning and should be easy to maintain.

- Wind Turbine Generator (WTG) (Figure 5C)

The WTG energy supply does not meet demand of continuous loads. Energy storage such as batteries, or a diesel backup are required.

If the WTG output is DC. the power can be conditioned for use in the same ways as PV energy supply. If the output is AC, then the WTG should be able to

- Wind Turbine Generator (WTG) (cont'd.)

  satisfy the characteristics described above for the diesel genset. This is unlikely, unless the WTG is grossly overdesigned so that the supply will exceed demand, even in poor wind.

CONVENTIONAL HYBRID DESIGN

- Conventional PV-Diesel Hybrid: (Figure 7)

  The natural concept for marrying PV with Diesel is to connect together 'one of each', as shown in Figure 7. Some designers consider paralleling the inverter with the diesel genset. Since these two sources have different waveform harmonics and different voltage regulation characteristics, they will not operate reliably in parallel.

  Assume a 100 KW peak system. The designer might size the PV array for this peak and the battery bank for the expected no-sun days. In fact, the PV array need only be sized for the average load, say 5 KW and the battery reserve can be a few hours.

  The backup diesel system is often arranged to simultaneously charge the battery and via the transfer switch to supply the load demand. A typical calculation will show that the diesel genset must supply about 40 KW to recharge the battery in an acceptable time after discharge due to no-sun. Since the peak load is 100 KW, the diesel genset must be rated at 140 KW.

  In this system design, all components (PV and diesel) operate much of the time inefficiently loaded.

- Conventional WTG-Diesel Hybrid

  If the WTG output is DC, then conventional practice could be to follow the design of Figure 7, substituting the WTG for the PV array.

  If the WTG output is AC, then the opportunities for design mistakes are greater.

  One method of controlling WTG frequency is to 'dump' excess energy into a dummy load. But what happens to voltage, frequency and waveform if a load-peak occurs at the same time as a large load-dump? In this design, the output of the WTG substitutes for the output of the inverter in Figure 7. All the same comments apply.

  A second method of coupling presumes that the diesel genset (rated below several hundred KW) is as infinitely stiff as the utility grid. It is not. The WTG output is synchronized by, and paralleled with the diesel genset. This can be accomplished in several ways, but the results are the same. The differences in voltage droop vs. load and in waveform harmonics will lead to early failure of the system. The better the wind condition the more light the load on the diesel, leading to poor fuel efficiency and high maintenance or failure.

- Remote Site, Inefficient Design: (Figure 8)

  Conventional practice is to set the PV or WTG accessories and diesel components in a room and add parasitic loads (fans, heaters, air conditioners) for heat removal or heat makeup.

  A natural tendency is to put the diesel genset in one room and the batteries, rectifiers, inverters and radio load (as applicable) in another. The diesel room as shown is not properly vented, so will require vents and fans (summer) and heaters (winter). The electronics room has the same problems. Energy-efficient design is described later.

MATCHING ENERGY SUPPLY TO LOAD DEMAND

This matching is the objective of energy-efficient power system design. One method is known generically as Cycle Charged Diesel or at Mechron, CYCLE CHARGE®.

The presence of a diesel in a hybrid system gives four key advantages:

- The PV array or WTG and tower can be downsized to meet the average load, not peak.
- The battery reserve can be downsized. As a rule of thumb, it can be set for the average load, times 9 hours equals nominal KW hours of storage required. Since the battery is to be shallow-cycled over a 30% depth, vs. normal service of 80%, we multiply the nominal reserve by 2.7.
- The diesel-generator plus battery system can be sized to carry the peak load.
- The diesel is capable of ventilating a power-room or generating and storing heat. Thus it can be integrated into a thermodynamically-efficient building module which will keep the power equipment and site equipment in a satisfactory environment over a wide ambient temperature range.

CYCLE CHARGED DIESEL

Figure 9 shows a CYCLE CHARGED DIESEL block diagram. The diesel genset is sized to meet the peak load, and shallow-cycles a battery storage unit, from 95% down to 65% of full charge, a 30% depth. Lead-acid or lead-antimony lift-truck batteries are used, designed for 1500 deep cycles from 100% down to 20%, an 80% depth. In shallow cycling, round-trip energy efficiency is better than 85%. Cycle life is increased from a normal 1500 to 5000, or 10 years at 1.5 cycles a day. The battery storage provides a natural interface with the PV system or WTG and eliminates duplication of system equipment.

Typical system cycling shown in Figure 10 is designed for a nominal 3 hours diesel ON, 4 hours OFF (25% duty cycle). During the ON cycle, the diesel, generator, rectifiers, etc. are operating at peak efficiency, above 80% of rated load. Periodically, at the end of the ON cycle, there is a battery EQUALIZE mode. (Yet another role for the diesel.) During the OFF cycle, energy is supplied from the battery.

The system is tolerant to peak overloads and for short periods can exceed the genset rated power by drawing energy from the battery. The system resembles a conventional system, plus controls and battery storage.

MATCHING ENERGY SUPPLY TO LOAD DEMAND (cont'd.)

Maintenance should be 1/3 normal. Life of most active components should be increased by as much as 4 times.

There are 2 CYCLE CHARGE designs: DC output for remote unattended navigation and communication sites, and AC output for small settlements.

- DC CYCLE CHARGE (Figure 11)

  The diesel drives an alternator which provides DC to the station battery. An alternator control determines the charging modes: soft-start, current-limit, voltage-limit, and equalize. A cycle-charge control determines the state of charge of the battery, availability of renewable energy (PV or wind), and controls diesel cycling via an engine control.

  Voltage limiting is provided to control DC output depending on the various states of the battery: charge/discharge/equalize.

  A microcomputer provides overall system monitoring and control of the environment: heating, venting, heat recovery, etc. A telemetry output can provide remote monitoring and control of the system. The system can be provided with dual-redundant Cycle Charged Diesels. For retrofit a single unit is offered and an existing diesel is used as a standby.

  For 12 to 15 KW DC systems, in-service fuel savings have been proven to be 70 to 75%. The field trial was from mid-1980 to mid-1982 and eighteen systems are operating now.

- AC CYCLE CHARGE (Figure 12)

  The AC output is required for small settlements. The system is different in design and represents a scale-up of the DC system (typically 5 to 12 KW) to a planned-for 10 to 150 KW rating.

  The system philosophy is to provide one Cycle Charged Diesel backed up by an existing-or-new conventional standby diesel. Total power range can be extended above 150 KW by using a higher-powered backup diesel.

  During the ON cycle, the diesel drives an AC generator (which delivers AC power to the load) and a DC motor/generator (M/G) via a one-way clutch. The M/G operates as a DC generator to charge the station battery.

  During the OFF cycle, the M/G reverts to a motor which is driven by the battery, and the AC generator continues delivering energy to the load.

  System components are minimized. There are neither rectifiers, inverters nor component duplication.

  Records of lightly-loaded diesel power-plants in small communities show gross generation of 2.2 KWH per litre as typical. Assuming a fully-loaded Cycle Charged Diesel can operate at 4.3 KWH per litre, the gross savings (in litres

- AC CYCLE CHARGE (cont'd.)

per KWH) are projected at 50%. Further efficiencies occur because, during the ON cycle the electrical components are running fully loaded and during the OFF cycle, some losses are eliminated while other system losses such as battery-motor losses are small.

- CYCLE CHARGE HYBRID

The PV or WTG interface in both DC and AC systems is via the station battery.

One 12 KW DC CYCLE CHARGE was hybrid combined with a 2.2 KW wind turbine generator. From August/83 to January/84 the WTG provided virtually all site energy, but the WTG failed due to extreme wind gusts.

Thus, in an ideal system, the diesel will run only during worst-case conditions of load-demand, or renewable-energy deficiency, or climate extremes.

- Remote Site, Efficient Design (Figure 13)

Figure 13 has been drawn so it is easy to compare with Figure 8 (inefficient design). It is not necessarily a recommended layout.

The battery bank, rectifiers and DC or AC power plant are located in the same room as the diesel. Insulated, fully-sealing, thermostat-operated vents are used. The diesels have been properly located with their cooling fans ducted to this type of vent, which either 'vents' for cooling or 'recirculates' for heat-conservation.

During the ON cycle of the Cycle Charged Diesel, fan-induced air flow takes care of ventilating the batteries. If cooling is needed, the vents will be open and air flow will carry off the parasitic heat load. If inside heat is needed, the vents will be closed during both the ON and OFF cycle. The diesel control will initiate an ON cycle if the building is too hot and needs ventilating or is too cold and needs heat.

During the OFF cycle, the large amount of heat stored in the engine block, the 170 litre engine oil sump, the batteries and the rectifiers will keep the site warm during cold weather with the vents closed. A heat-recovery system (coolant or exhaust) is an available option, for extreme cold climates.

The radio room can be vented, via a fan for heating or cooling, to the diesel room. If the radio equipment is in a separate building, it can be vented or heated with separate fans and heaters.

To the extent possible, 'parasitic' site loads should be DC-operated from the station battery to avoid conversion losses. If there is a very large but short-duration load device at the site, the control system can include a sensor which will cause the diesel to run for the required short period. During this period, the station battery will also be charged.

DESIGN STRATEGIES FOR MARKET APPLICATIONS

The following comments are confined to industrial applications, particularly where reliable power is essential, such as remote sites and settlements.

U.S. Department of Commerce statistics show that from 1961 to 1981 some 435,000 diesel gensets were sold. Of these, we estimate 25% were applied to prime power. Diesel life is about 20 years, so total prime power population is some 125,000. The sales statistics are segmented into seven power-ratings from under-14 KW to over-1000 KW. The segment under-14 KW accounts for 26% of sales or a possible population of 31,000 units. The segments from 14 KW to 200 KW account for 45% of sales or 56,000 units.

We made an estimate of the key Canadian users then extrapolated and arrived at an estimate of 15,000 units in service, for critical industrial applications.

- Unattended radio sites are predominantly 8 to 15 KW size and include 2 or 3 gensets each.
- Remote settlements vary in size from 10 KW to several hundred kilowatts. Half the applications are probably powered by 200 KW or smaller gensets and include typically 2 or more units per system.

The largest market potential, within these applications, is probably a diesel-hybrid for the replacement of worn-out and energy-inefficient systems.

A second market potential is retrofit of energy-efficient diesel controls combined with a renewable-energy system to improve operating and maintenance costs of systems which still have useful life.

The third potential market is new growth. Since Canada's infrastructures (communications, navigation, defence) have largely been built, new growth in Canada is foreseen to be smaller and rate of growth is probably falling.

The last, but largest market potential is for infrastructures for developing countries.

Whatever the industrial market, energy-efficient packaging of an integrated system is essential. For replacement and retrofit, this may be done economically by upgrading the equipment layout, insulation and venting of existing buildings.

Life-cycle costing and payback calculations are useful techniques in convincing the owner to invest in new or replacement equipment.

CONCLUSIONS

- Power system designs in the past have taken the path of least resistance: overdesign. This was 'optimal' when fuel was cheap.
- Optimal system design is complex because it involves trade-off of alternative power sources including the 'mix' of sizes for diesel, PV array, WTG and battery size. Load Duration Curves for small settlements are necessary but are not available. Funding should be allocated to establish a 'generic' set of curves.

CONCLUSIONS (cont'd.)

. Each settlement and site is specific as to availability of renewable energy and the cost of transporting fuel by air, road, ship or snow train. Annual fuel costs for a 15 KW radio site range typically from \$20,000 by road to \$40,000 by air. Since it is uneconomical to custom-design a power system for every settlement or site, there should be a small number of standard designs and sizes.

. An integrated power system design for essential loads includes the building and environmental controls, a renewable-energy source, an energy-efficient diesel, an energy-storage device and a microcomputer control system. End users should be able to select an integrated system to meet their particular needs.

. More funding should now go into real-world, real-load applications. Testing on dummy loads can be misleading. Once the Load Duration Curve and the renewable-energy supply are known, good systems can be designed.

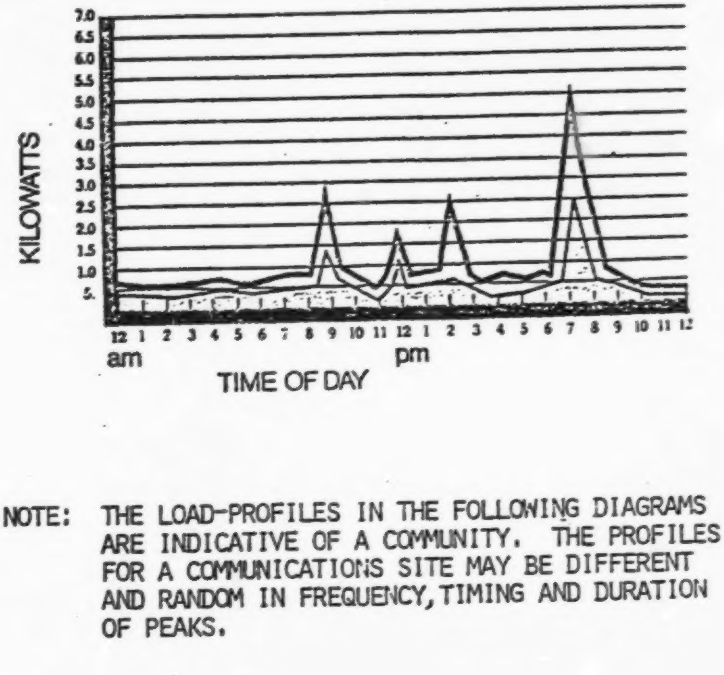
. A Cycle Charged Diesel/renewable hybrid permits radical downsizing of the renewable-energy source and battery. It makes more effective use of the battery by ensuring it is shallow-cycled. System components are operated at full load and best efficiency in a controlled temperature. Maintenance is reduced and reliability is enhanced. The dual-power sources offer backup to one another except that the renewable-energy system is power-limited. The system is tolerant to large peak-to-average power ratios and adapts automatically to fluctuations in average load level. Underloaded, the system will run less; heavily loaded, it will run more often.

. Savings in fuel of 70 to 75% are possible. Maintenance savings can be 65 to 70%. Existing equipment can be upgraded. Paybacks in the range 2 to 4 years are possible.

FIGURE 1

LOAD DEMAND

(500 KwH and 200 KwH Per Month User)



NOTE: THE LOAD-PROFILES IN THE FOLLOWING DIAGRAMS ARE INDICATIVE OF A COMMUNITY. THE PROFILES FOR A COMMUNICATIONS SITE MAY BE DIFFERENT AND RANDOM IN FREQUENCY, TIMING AND DURATION OF PEAKS.

FIGURE 2

DETERMINING INRUSH KVA

TYPE OF EQUIPMENT	POWER FACTOR	INRUSH %	DURATION
INDUCTION MOTOR OR MG SET	0.75	500-800	1-30 SEC.
COMPUTER CENTRAL PROCESSOR UNIT	0.9-0.85	600-1000	2-6 CYCLES
COMPUTER PERIPHERALS	0.8	500-800	1-30 SEC.
PROCESS INSTRUMENTS & CONTROLS	0.85	300-500	2-6 CYCLES
FLUORESCENT LIGHTS (CORRECTED TYPE)	0.95	300-600	1 CYCLE
INCANDESCENT LIGHTS	1.0	600-1500	2-6 CYCLES
REGULATED DC POWER SUPPLY (OR BATTERY CHARGERS)	0.6-0.8	600-1000	2-6 CYCLES
UNREGULATED DC POWER SUPPLY	0.9	600-1000	2-6 CYCLES
TRANSFORMER	SAME AS LOAD	1000	1 CYCLE
MAGNETIC LINE REGULATORS (AUTO-TRANSFORMER)	0.6-0.8	200-300	1 CYCLE
FERRORESONANT TYPE LINE REGULATORS	0.5 LEAD TO 0.5 LAG	600-1000	1-3 CYCLES
SOLENOIDS, RELAYS AND CONTACTORS	0.5	1000	2-3 CYCLES

FIGURE 3

SAMPLE LOAD CALCULATION, REMOTE RADIO SITE

RADIO ROOM LOADS:

ASSUME RADIO LOAD IS 750 WATTS	WATTS
RECTIFIERS 2 x 50 AMP 24 V.D.C. =	2800
COOLING FAN & MISC. VENTS	700
LIGHTING 4 80 WATT FIXTURES	320
DEHYDRATOR	600
HEATING 2 x 1500 WATT	3000
TOWER LIGHTS 4 x 130	520
WALL PLUGS OUTSIDE LIGHT, ETC.	700
	8640

NOTE: IF COOLING FAN IS SUBTRACTED
LOAD WILL BE APPROX. 8.0 KW

DIESEL ROOM LOADS:

BATTERY CHARGING RECTIFIERS x 2	400
FUEL LIFT PUMPS	800
COOLING FAN	500
LIGHTING & WALL OUTLETS	700
ENGINE HEATERS	250
	2650

LOAD = 2.7 KW

RESULT:

MOST PRIME POWER SITES ARE 10-15 KW	11290

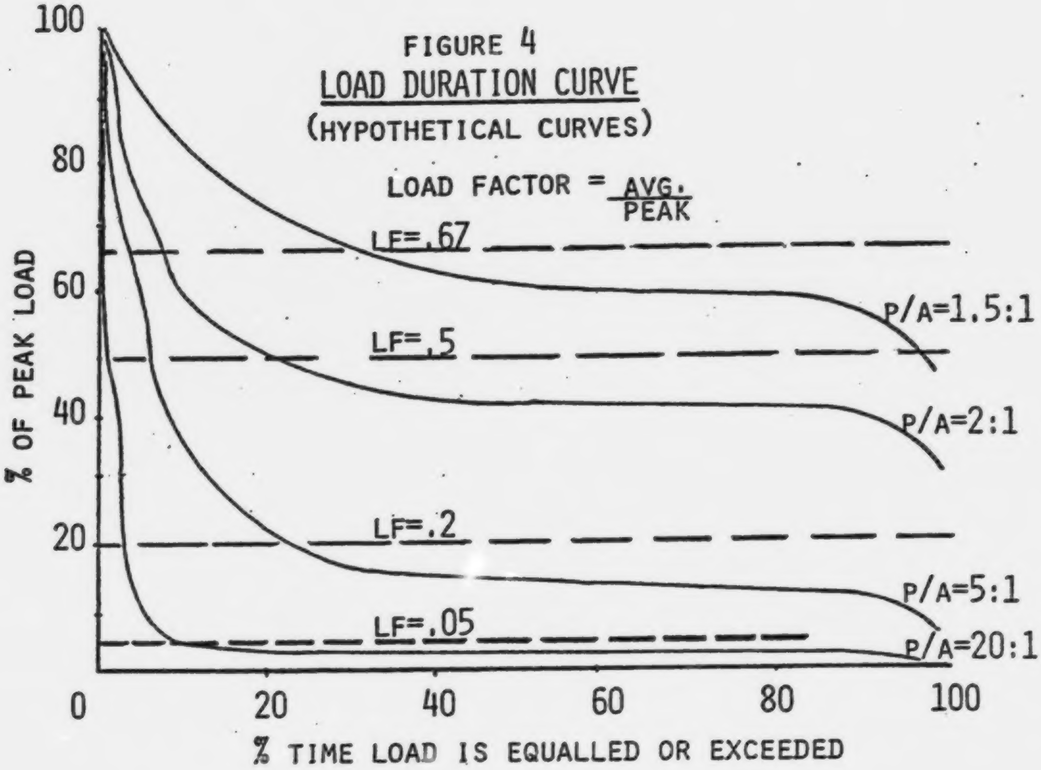


FIGURE 4

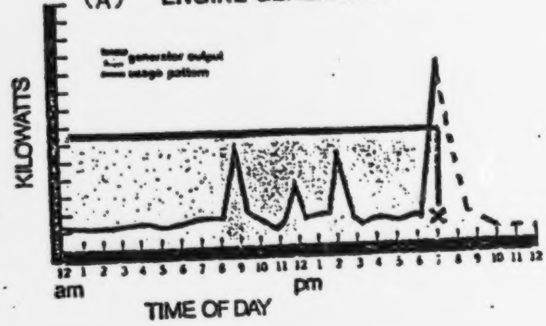
LOAD DURATION CURVE

(HYPOTHETICAL CURVES)

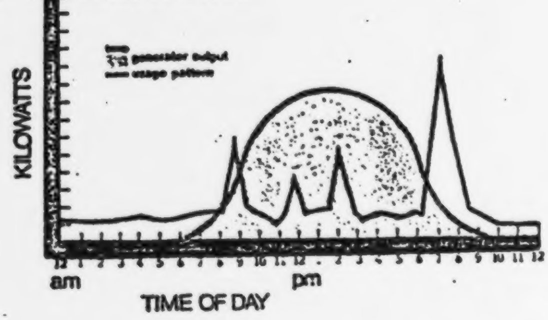
FIGURE 5

SUPPLY CHARACTERISTICS

(A) ENGINE GENERATOR



(B) PHOTOVOTAIC



(C) WIND GENERATOR

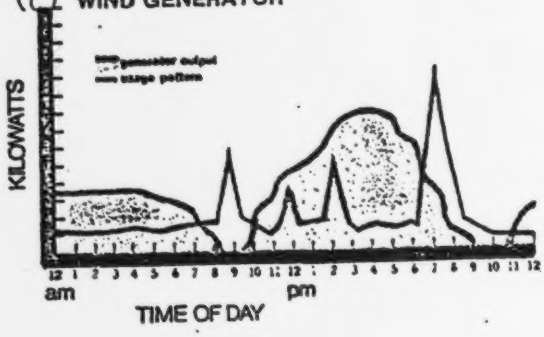


FIGURE 6

SUPPLY VS. DEMAND

CONVENTIONAL ENGINE GENERATOR

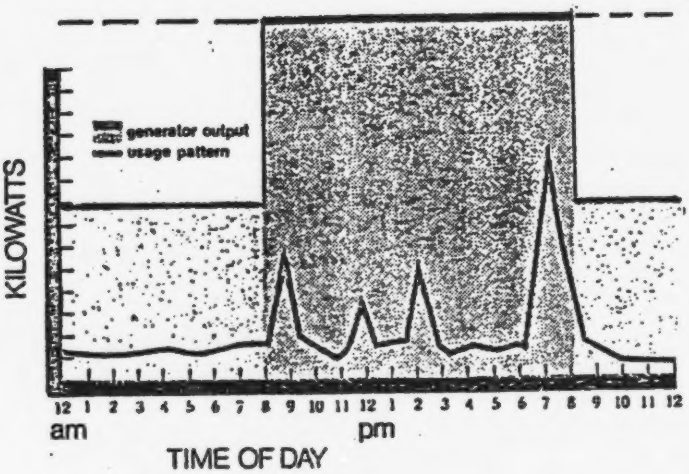


FIGURE 7

COVENTIONAL PV/DIESEL

HYBRID SYSTEM

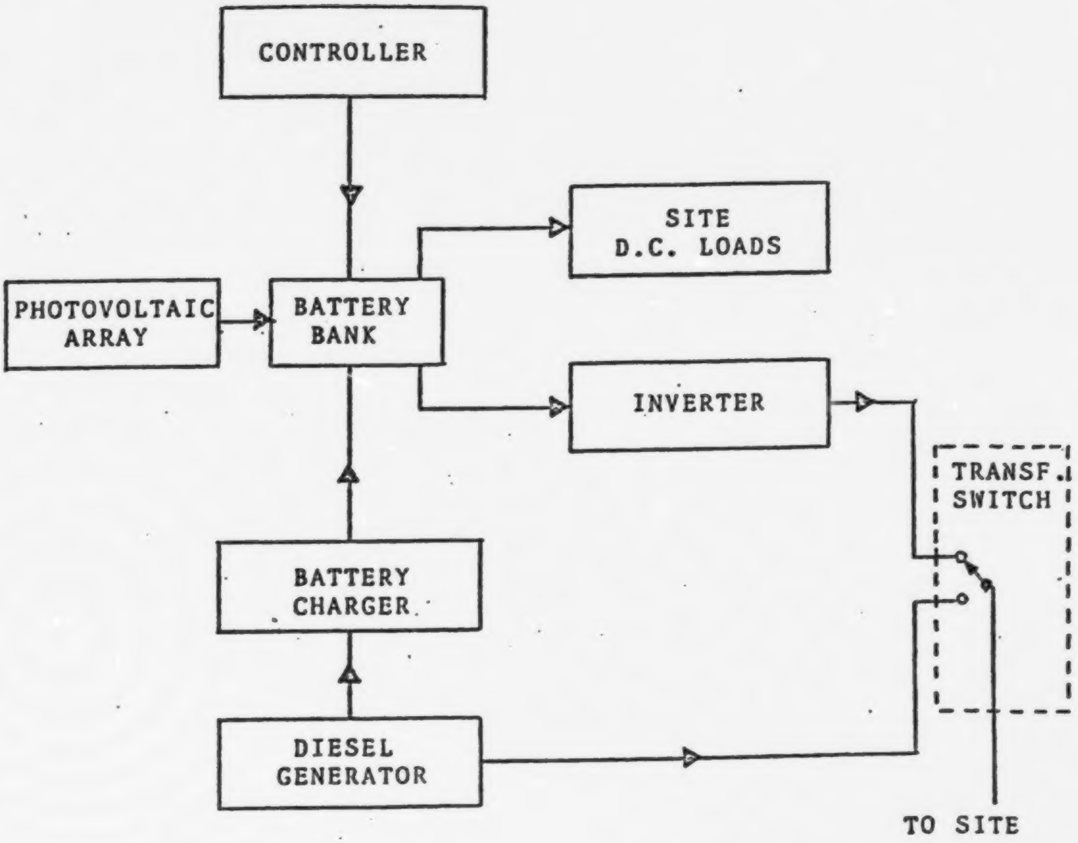
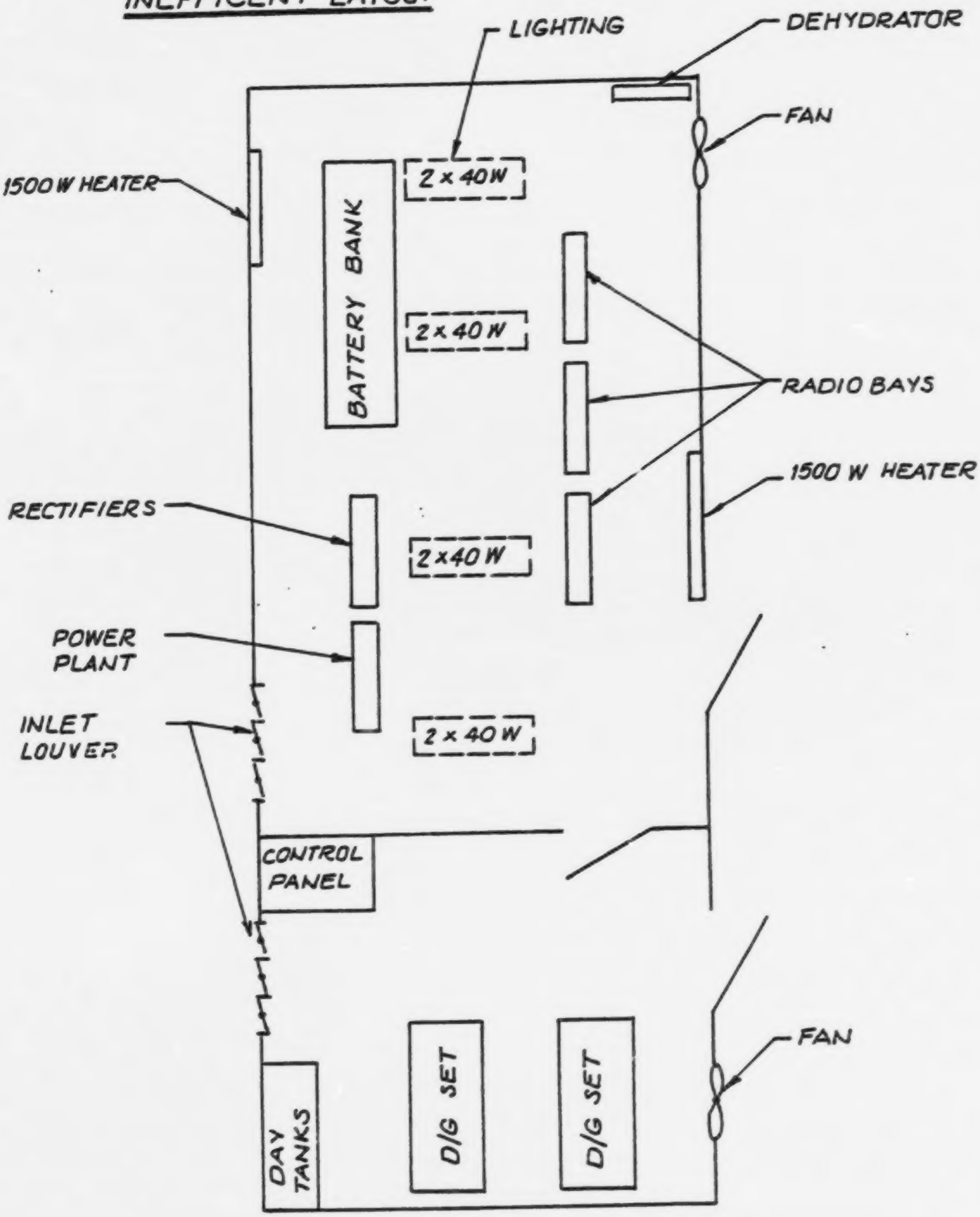

CONTROLLER
SITE D.C. LOADS
PHOTOVOLTAIC ARRAY
BATTERY BANK
INVERTER
TRANSF. SWITCH
BATTERY CHARGER
DIESEL GENERATOR
TO SITE

FIGURE 8
REMOTE SITE
INEFFICENT LAYOUT


LIGHTING
DEHYDRATOR
FAN
1500 W HEATER
2 x 40 W
BATTERY BANK
2 x 40 W
RADIO BAYS
1500 W HEATER
RECTIFIERS
2 x 40 W
POWER PLANT
INLET LOUVER
2 x 40 W
CONTROL PANEL
FAN
DAY TANKS
D/G SET
D/G SET

ADD WALL OUTLETS
TOWER LIGHTING

FIGURE 9

CYCLE CHARGED DIESEL, BLOCK DIAGRAM

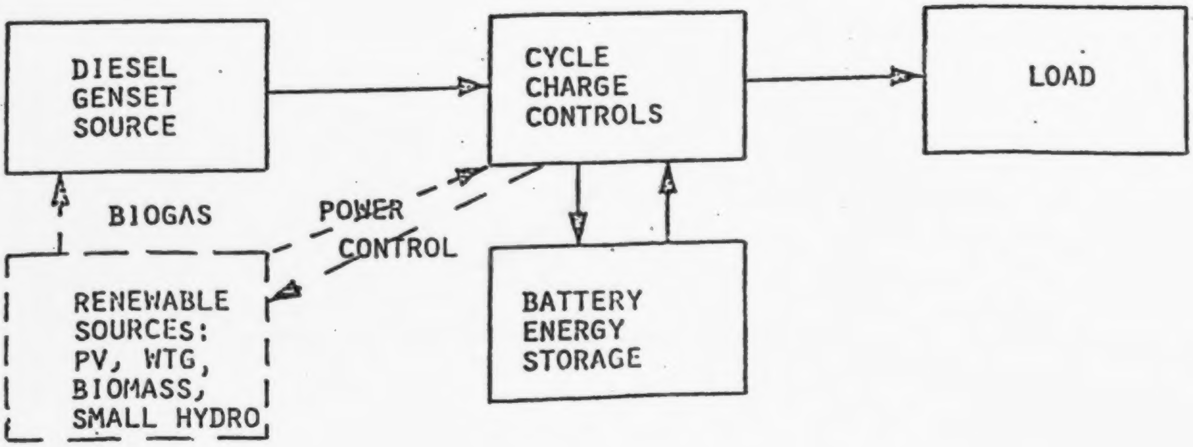

DIESEL GENSET SOURCE
CYCLE CHARGE CONTROLS
LOAD
BIOGAS
POWER
CONTROL
RENEWABLE SOURCES: PV, WTG, BIOMASS, SMALL HYDRO
BATTERY ENERGY STORAGE

FIGURE 10

SUPPLY VS. DEMAND

CYCLE CHARGED DIESEL

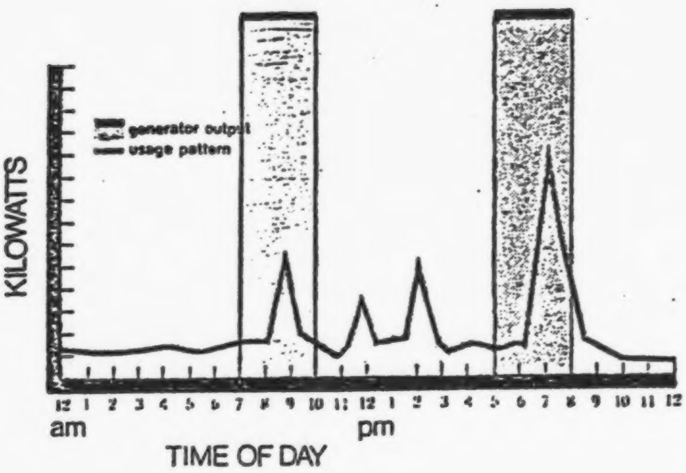


FIGURE 11

D.C. CYCLE CHARGE
SERIES 2000

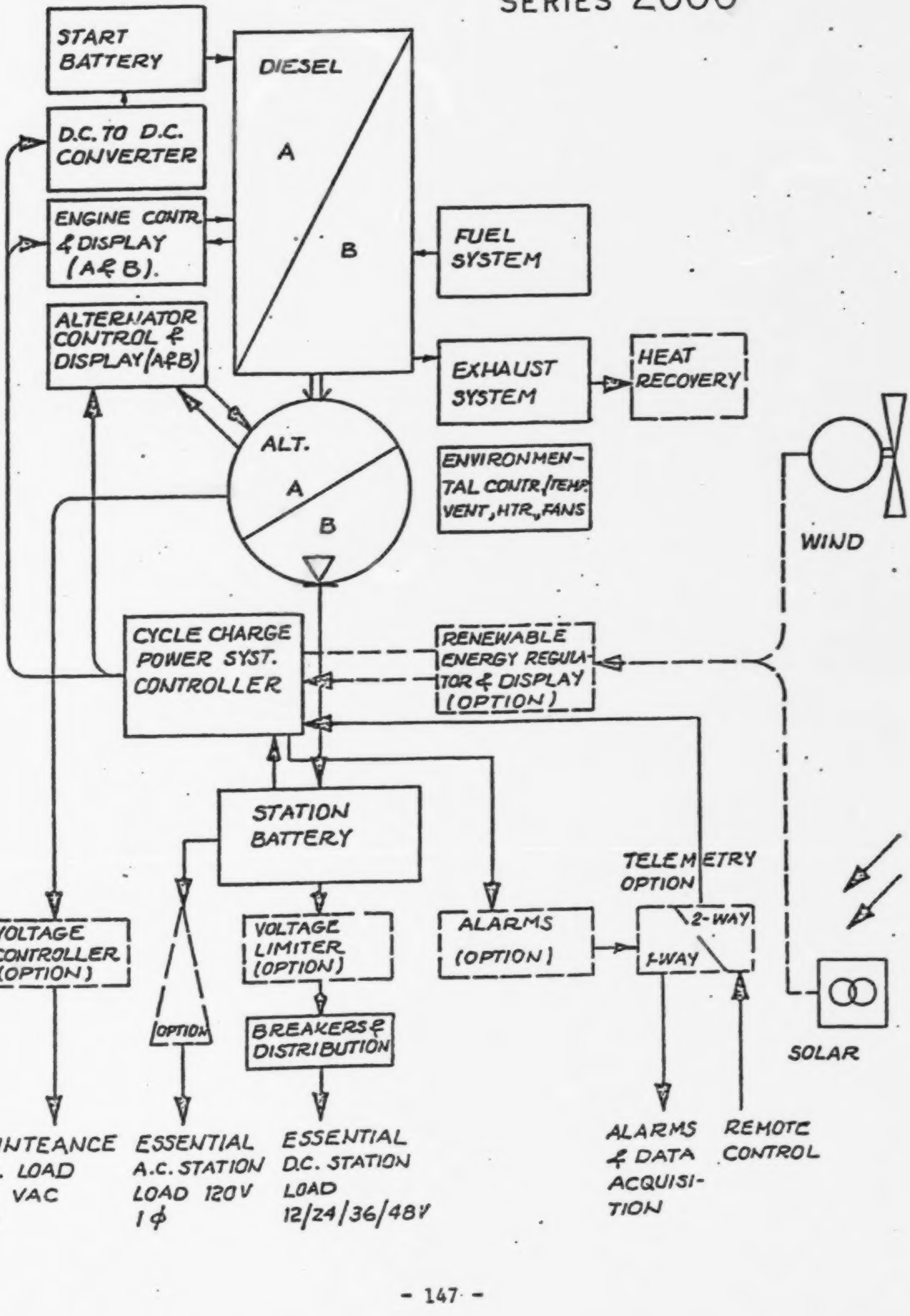

START BATTERY
DIESEL
A
B
D.C. TO D.C. CONVERTER
ENGINE CONTR. & DISPLAY (A&B).
FUEL SYSTEM
ALTERNATOR CONTROL & DISPLAY (A&B)
EXHAUST SYSTEM
HEAT RECOVERY
ALT.
A
B
ENVIRONMENTAL CONTR. (TEMP. VENT, HTR., FANS
WIND
CYCLE CHARGE POWER SYST. CONTROLLER
RENEWABLE ENERGY REGULATOR & DISPLAY (OPTION)
STATION BATTERY
TELEMETRY OPTION
VOLTAGE CONTROLLER (OPTION)
OPTION
VOLTAGE LIMITER (OPTION)
BREAKERS & DISTRIBUTION
ALARMS (OPTION)
2-WAY
1-WAY
SOLAR
MAINTEANCE A.C. LOAD 120 VAC 1 φ
ESSENTIAL A.C. STATION LOAD 120V 1 φ
ESSENTIAL D.C. STATION LOAD 12/24/36/48V
ALARMS & DATA ACQUISITION
REMOTE CONTROL

FIGURE 12

A.C. CYCLE CHARGE
SERIES 4000

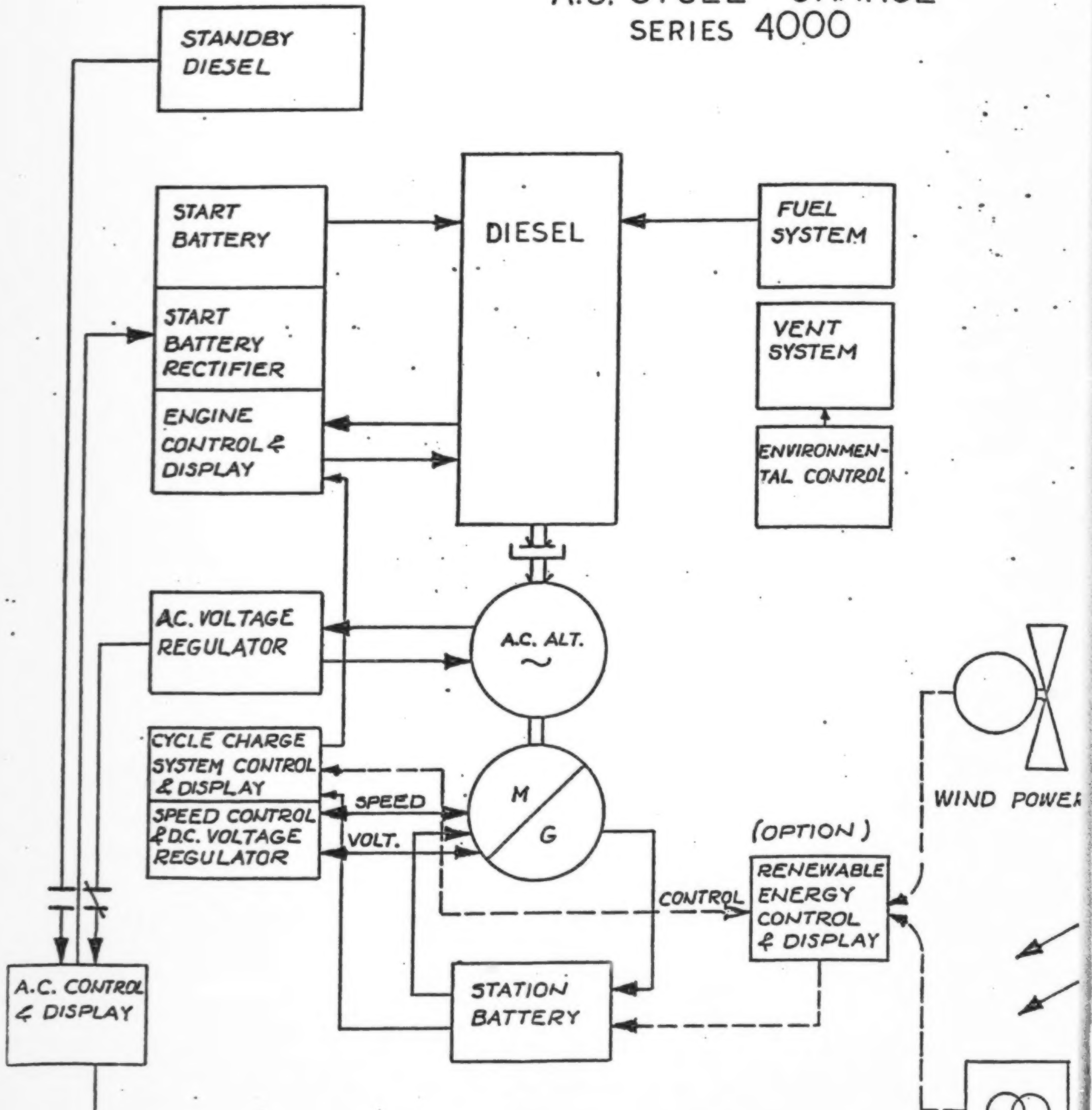
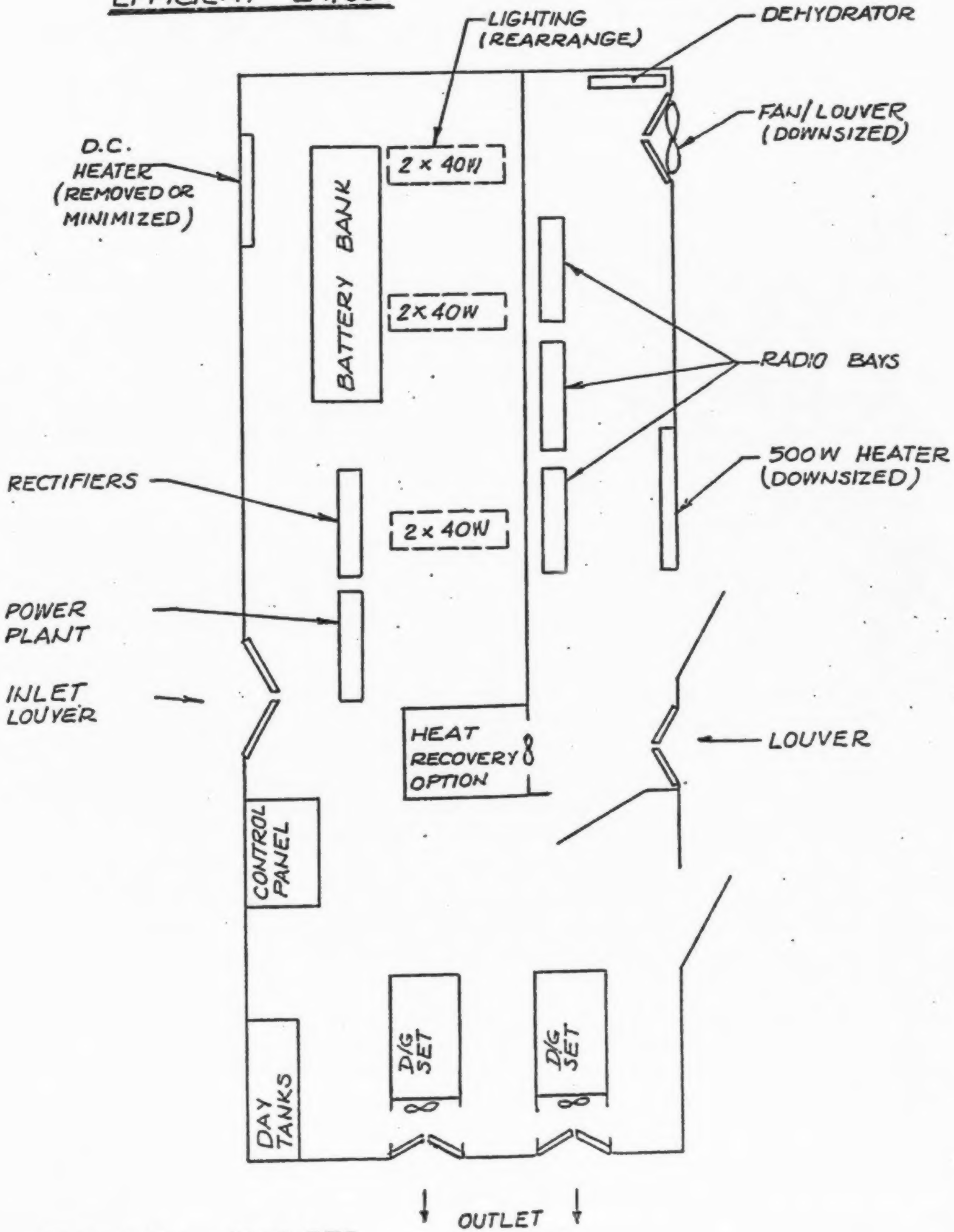

STANDBY DIESEL
START BATTERY
DIESEL
FUEL SYSTEM
START BATTERY RECTIFIER
VENT SYSTEM
ENGINE CONTROL & DISPLAY
ENVIRONMENTAL CONTROL
AC. VOLTAGE REGULATOR
A.C. ALT.
~
CYCLE CHARGE SYSTEM CONTROL & DISPLAY
SPEED CONTROL & D.C. VOLTAGE REGULATOR
SPEED
VOLT.
M
G
WIND POWE
(OPTION)
RENEWABLE ENERGY CONTROL & DISPLAY
CONTROL
STATION BATTERY
A.C. CONTROL & DISPLAY
SOLAR POWE

FIGURE 13

REMOTE SITE EFFICIENT LAYOUT


LIGHTING (REARRANGE)
DEHYDRATOR
FAN/LOUVER (DOWNSIZED)
D.C. HEATER (REMOVED OR MINIMIZED)
2 × 40W
BATTERY BANK
2 × 40W
RADIO BAYS
500W HEATER (DOWNSIZED)
RECTIFIERS
2 × 40W
POWER PLANT
INLET LOUVER
HEAT RECOVERY OPTION
LOUVER
CONTROL PANEL
DAY TANKS
D/G SET
D/G SET
OUTLET LOUVERS

ADD WALL OUTLETS
TOWER LIGHTING

AUG 28 1984

JACOBS®
WIND ELECTRIC COMPANY
2720 FERNBROOK LANE
MINNEAPOLIS, MINNESOTA 55441-3379
TELEPHONE (612) 559-9361
TELEX 290435

3.2 Jacobs maintenance and other information

20 August 1984

John D. Dure
Mechron Energy LTD
2437 Kaladar Avenue
Ottawa, Ontario
Canada K1V 8B9

Dear John:

Thanks for the call. I am way behind on my correspondence and probably have not even written to thank George Mayo for the time he spent with me when I was in Ottawa in June. If I have neglected that courtesy, I will say thanks now. We had a good meeting and I am sure that there are opportunities for us to work together.

Summary wind data for Battle Harbour Labrador is enclosed. Using these numbers, we estimate annual production of 31,240 KWH from our 10 KW unit. December would be the high month with 3006 KWH and July the low month with 1770 KWH. For our 12.5 KW unit, the annual production would be 33,655 KWH with extremes of 3301 and 1841 KWH.

You mentioned that the average village power load was about 9 KW. That extends to 78,840 KWH per year (9x24x365). Thus, one of our 10 KW units could produce about 40 percent of the annual power requirement if you ignore all losses, i.e. batteries, inverters, lines, etc. Also, I suspect that the load is skewed toward the short daylight winter months. In any case, this will give you an idea of the production potential of our wind systems and we can start to fine tune the configuration.

The output of the wind turbine is 0-180 VAC, 3 phase, 0-40 Hz. In our standard configuration, the AC is rectified and used to charge a 120 VDC battery bank. We recommend the use of battery banks with a minimum storage capacity of 800 A-H. The battery charger also provides field current for the windplant alternator.

We also offer a "dual" battery charger with two input ports, one for the windplant and the second from an auxiliary power source (diesel). In this case, logic with the unit will provide a contact closure to start a genset when low batteries are detected.

20 August 1984
Page 2
Mr. John D. Dure

Both battery chargers permit connection of a "heat load manager". This device diverts excess wind energy to an auxiliary heat load when the batteries are fully charged.

In reviewing your literature, I note that you normally work with lower voltages (24,48 VDC). This would not preclude the use of our windplant. We know that there are other battery chargers and DC to DC converters on the market which could be used to connect our windplant to these lower voltages. The only special requirement would be the need to provide field current to the windplant alternator.

Literature and pricing information is enclosed. Our distributor in Newfoundland is Terra Nova Marine, 181 Mundy Pond Road, P.O. Box 7056, St. John's, Newfoundland, A1E 3Y3. The principals, Mike Gulliver and Lloyd Hollett, have attended our installation/maintenance class here in Minneapolis and are prepared to work with you on this system.

I trust that this letter answers most of your immediate questions. Please feel free to call me or Terra Nova if you require additional information.

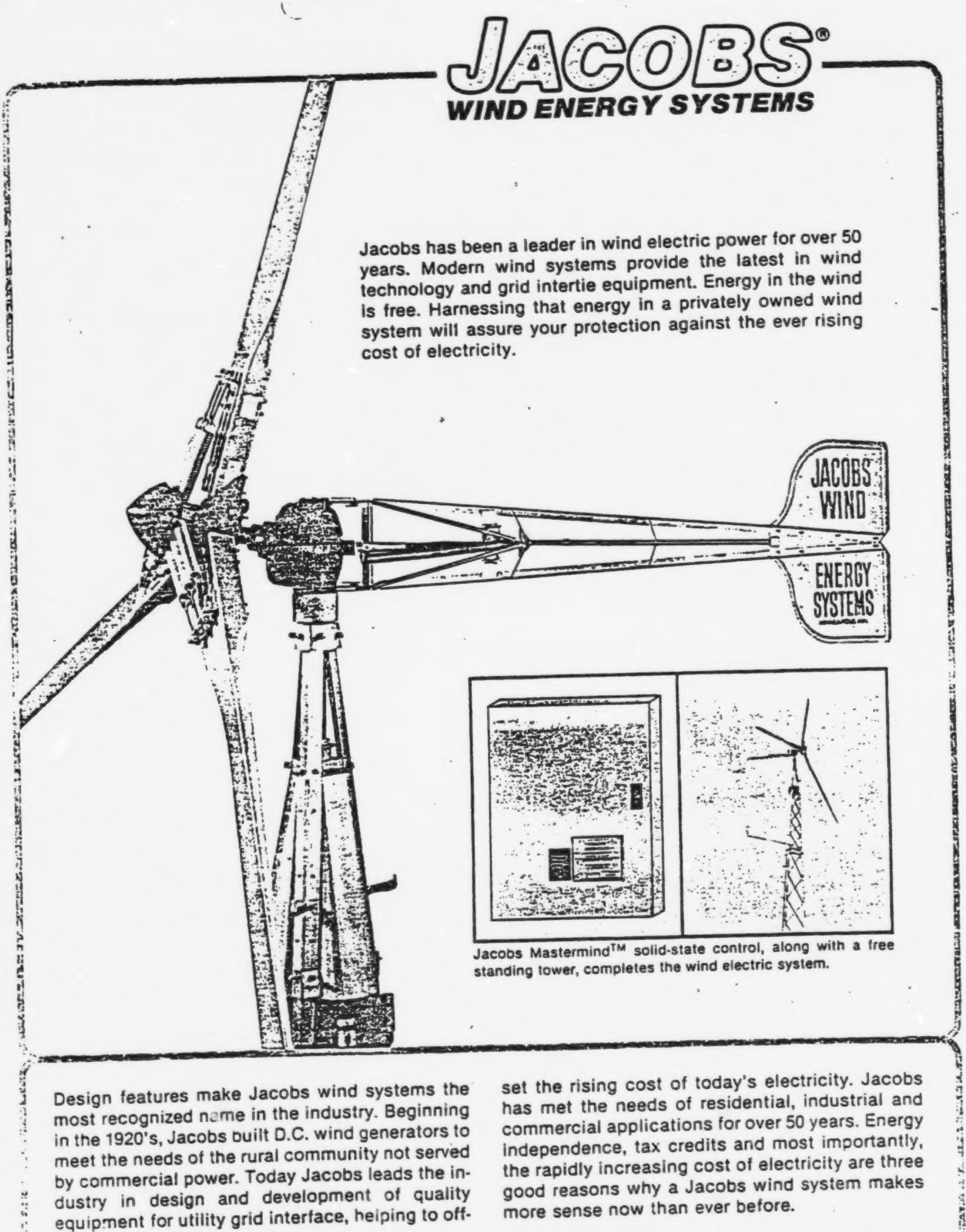
Best Wishes,

JACOBS WIND ELECTRIC COMPANY

Kenneth M. Lampert
Manager - International Sales

KML/ag

Enclosure



JACOBS®

WIND ENERGY SYSTEMS

Jacobs has been a leader in wind electric power for over 50 years. Modern wind systems provide the latest in wind technology and grid intertie equipment. Energy in the wind is free. Harnessing that energy in a privately owned wind system will assure your protection against the ever rising cost of electricity.

Jacobs Mastermind™ solid-state control, along with a free standing tower, completes the wind electric system.

Design features make Jacobs wind systems the most recognized name in the industry. Beginning in the 1920's, Jacobs built D.C. wind generators to meet the needs of the rural community not served by commercial power. Today Jacobs leads the industry in design and development of quality equipment for utility grid interface, helping to offset the rising cost of today's electricity. Jacobs has met the needs of residential, industrial and commercial applications for over 50 years. Energy independence, tax credits and most importantly, the rapidly increasing cost of electricity are three good reasons why a Jacobs wind system makes more sense now than ever before.

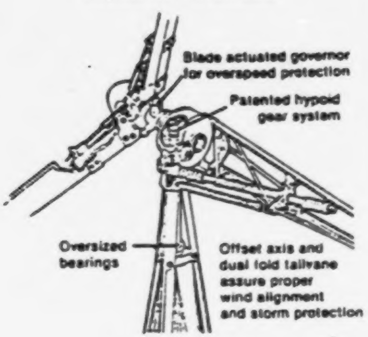
Design Features

Available are:

1. A 60 Hz grid intertie system which is compatible with single phase 228-252 VAC, or 3 phase, 240 VAC Delta or 208 VAC 3 phase wye. Other 60 Hz voltages available through isolation transformers. 240 VAC nominal available in 50 Hz.
2. A battery charging system for connection to a nominal 120 volt lead-acid D.C. battery bank.
3. A heat control system for constant or thermostatically controlled resistance heating load.

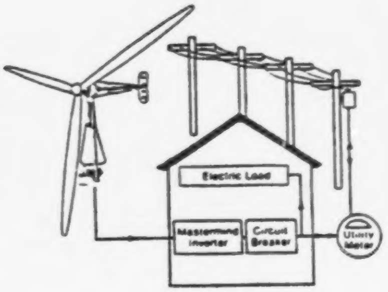
Jacobs wind energy systems are available for remote locations where no utility grid exists. By interfacing a wind system with the present engine-generator you can cut your costs by reducing the load on your generator.

All parts weather protected


Blade actuated governor for overspeed protection
Patented hypoid gear system
Oversized bearings
Offset axis and dual fold tailvane assure proper wind alignment and storm protection

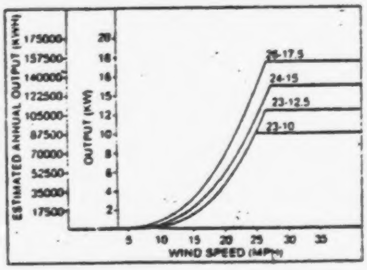
Utility Grid Intertie

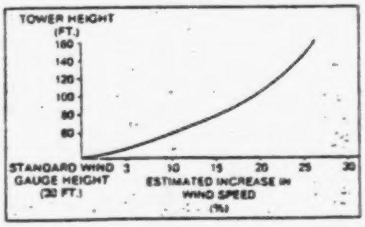
The grid intertie system, preset and factory tested, is installed by your Jacobs dealer. The inverter has a safety system to disconnect the unit from the power grid in the event of a power line failure. This is important in satisfying the requirement of the utility company. The inverter changes the wind system output to A.C. power compatible with the utility grid. Federal regulations require the utilities to purchase excess power. A wind energy system can substantially reduce your monthly electric bill.


Electric Load
Mastermind Inverter
Circuit Breaker
Utility Meter

Specifications

Output Power:	Utility Intertie			
	10 KW	12.5 KW	15 KW	17.5 KW
Type	Horizontal Upwind Design			
Performance:				
Cut-In Wind Speed	8 MPH	8 MPH	8 MPH	8 MPH
Peak Output At	25 MPH	27 MPH	28 MPH	27 MPH
Rotor:				
Rotor Type	3 Blade Variable Pitch			
RPM at Peak Output Power	200 ±	205 ±	220 ±	215 ±
Rotor Diameter	23 FT.	23 FT.	24 FT.	26 FT.
Transmission:				
Type	Offset Hypoid Gear Type			
Ratio—Generator to Rotor	1:6	1:6	1:6	1:6
Generator:				
Type	Brushless 3φ Alternator			
Output	25 KVA, 3φ, 0-180 Volts			
Protection:				
Yaw Control	Dual Fold Tailvane			
Rotor Speed Control	Blade Actuated Governor			
Hi Wind/Storm	Offset Rotor Axis			
Tower:				
Type	Free Standing, 3 Legs, Galvanized Steel			
Heights Available	Nominal 60-160 Feet			
Brake:				
Type	Mechanical Caliper Disk Brake			





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2720 Fernbrook Lane, Minneapolis, MN 55441, (612) 559-9361

Printed in U.S.A. Form 130 783

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5/1/84

JACOBS®
WIND ELECTRIC COMPANY

LIST PRICES

Windplants

Models[2]	Price (U.S. Dollars)[1]
23-10	13,100.00
23-12.5	14,500.00
24-15	17,100.00
26-17.5	20,500.00

Mastermind Controls

Energy Phasers[3]	Price (U.S. Dollars)[1]
MEP-10 60HZ	2,500.00
MEP-10 50HZ	2,500.00
MEP-12.5 60HZ	2,900.00
MEP-12.5 50HZ	2,900.00
MEP-15 60HZ	3,300.00
MEP-15 50HZ	3,300.00
MEP-17.5 60HZ	3,600.00
MEP-17.5 50HZ	3,600.00

Battery Charging	Price (U.S. Dollars)[1]
MBC-10 Series 1	2,540.00
MBC-10 Series 2	2,780.00
MBC-10 Series 3	3,050.00
Upgrade Kit (Series 1 to 2 or 2 to 3)	420.00

Heating Control	Price (U.S. Dollars)[1]
MHC-10 Series 1	1,000.00
MHC-10 Series 2	2,000.00
MHC-12 Series 1	1,500.00
MHC-12 Series 2	2,500.00

Towers

Models	Height	Price (U.S. Dollars)[1]
SSV-C20[2]	60 feet (18.3 meters)	2,990.00
	80 feet (24.4 meters)	4,160.00
	100 feet (30.5 meters)	5,640.00
	120 feet (36.6 meters)	7,630.00
SSV-D20[3]	60 feet (18.3 meters)	3,160.00
	80 feet (24.4 meters)	4,510.00
	100 feet (30.5 meters)	6,240.00
	120 feet (36.6 meters)	8,180.00
	140 feet (42.7 meters)	11,180.00

Anchors

Models	Height	Price (U.S. Dollars)[1]
SSV-C20	60 foot Tower (18.3 meters)	400.00
	80 foot Tower (24.4 meters)	450.00
	100 foot Tower (30.5 meters)	500.00
	120 foot Tower (36.6 meters)	1,050.00
SSV-D20	60 foot Tower (18.3 meters)	450.00
	80 foot Tower (24.4 meters)	650.00
	100 foot Tower (30.5 meters)	750.00
	120 foot Tower (36.6 meters)	1,050.00
	140 foot Tower (42.7 meters)	1,150.00

Notes—Windplants and Controls

1. Prices F.O.B. Factory, Minneapolis, Minnesota, U.S.A.; export packaging costs extra.
2. First two digits designate blade diameter in feet. Second two digits designate maximum KW output.
3. Please specify phase to phase and phase to neutral utility system voltages when ordering. An interface transformer ($1,600) may be required.

Notes—Towers & Anchors

1. Prices F.O.B. Tower Manufacturer, Peoria, Illinois or Sioux City, Iowa, U.S.A. Export packaging costs extra.
2. Use with 23-10, 23-12.5, and 23-15.
3. Use with 23-17.5.

Jacobs wind systems are composed of four major components: windplant, controls, tower and anchors. Each category lists the options available.

Windplants

The windplant consists of the top seven feet of the tower, including the alternator, brake, driveshaft, gearbox, blades, and tailvane. The first two digits of the model number represent the rotor diameter in feet and the second two digits represent the maximum KW output.

Example: Windplant Model 24-15 has a 24-foot blade span and a maximum output of 15 KW.

Mastermind Controls

Jacobs offers three types of controls to permit the wind energy system to function in one of three ways:

1. Mastermind Energy Phasers (MEP)—
   AC power with direct intertie to the grid.
2. Mastermind Battery Chargers (MBC)—
   DC power with battery storage.
3. Mastermind Heat Controllers (MHC)—
   Power for heating only.

Energy Phasers

Grid intertie controls are available for 50 or 60 cycle operation (depending on your local utility) for each windplant. The two numbers after the dash in the model number must match the last two digits of the windplant model number.

Battery Charging

Battery charging controls are offered in only the 10 KW size with three options.

Series 1 is the battery charging control.
Series 2 is the battery charging control with one alternative load circuit.
Series 3 is the battery charging control with two alternative load circuits.

Jacobs advises the use of at least one alternative load circuit.

NOTE: For higher production at lower wind speeds, it is possible to utilize the 26-17.5 windplant with the 10 KW battery charger. While the maximum production will not exceed 10 KW, the longer blades will provide a larger wind swept area and therefore, with wind speeds under 25 miles an hour, higher production.

Heating Controller

The Heat Load Controller is also offered in only the 10 KW and 12.5 KW sizes with the option of one alternative load circuit (Series 2). The larger windplant can be used with maximum production again determined by the size of the heat load controller.

Towers

Tower heights are determined by the site surroundings. The tips of the blades should be a minimum of 35 feet above any obstructions within several hundred feet. The model is determined by the windplant size. Windplant models 23-10, 23-12.5 and 24-15 use tower model SSV-C20. Windplant model 26-17.5 and towers over 120 feet (36.6 meters) use tower model SSV-D20.

Anchors

Anchor models and sizes correspond directly with tower models and sizes.

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TELEX 290435

NEW BATTERY CHARGING CONTROLS	LIST PRICES
Battery Charger:	
10 KW	$ 2540.
12.5 KW	$ 2800.
Dual Battery Charger:	
10 KW	$ 3500.
12.5 KW	$ 4000.
Heat Load Manager:	
10 KW	$ 1340.
12.5 KW	$ 2000.

JACOBS MAINTENANCE SCHEDULE

Semi-Annually:

(a) First gearhead oil change. (Subsequent changes annually)
(b) Check gearhead seals.
(c) Lubricate driveshaft U-joints. (Chevron SRI-2)
(d) Lubricate brake winch and crank.
(e) Lubricate blade brackets.
(f) Check brake assembly and pads for wear.
(g) Check blades for out of balance conditions.
(h) Check and torque all blade bolts.
(i) Check alternator wedge blocks for tightness.
(j) Check governor spring tension and adjust as required.
(k) Check and tighten all bolts on the windplant and tower.
(l) Check electronics (with power off) to verify that power connections are tight. Clean heat sink to ensure good thermal efficiency.

Annually:

(a) Lubricate lower gearhead pinion shaft bearing. (Chevron SRI-2)
(b) Lubricate tower cap turntable roller bearing. (Chevron SRI-2)
(c) Apply a small amount of oil to tail hinge bearing. Spray graphite on the spring rod and spring bushing.
(d) Lubricate brake studs and bolts. (Graphite)
(e) Check all bearings and gears for audible noise. (Use an acoustic bearing detector)
(f) Lubricate driveshaft bearing. (Chevron SRI-2)
(g) Inspect all welds.
(h) Check wind turbine and tower for bare or rusted spots. Clean and paint spots with cold galvanizing as required.
(i) Visually check blade surface conditions and repair as required.